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A New Code of Reinforced Concrete Rules.

Elsewhere in this issue will be found the full report of the joint committee of British architectural and building associations and government bureaus, which has been working for many months to adopt a code of rules for the design and construction of reinforced concrete works.

This report is both interesting and important as emanating, primarily, from an institution of architects since it indicates that the Royal Institute of British Architects, the prime mover in the organization of the committee, is of opinion that reinforced concrete is to be recognized as an accepted material for general structural purposes. The report embodies a fairly complete set of general rules to govern the use of reinforced concrete without limitation in regard to the classes of buildings to which it may be applied. In other words, if there is any such limitation in the mind of this body of architects and builders, the limitation is neither set forth nor even mentioned in the report. It is fair to assume, therefore, that the committee intended no such limitation, especially in view of the fact that some of the regulations recommended for the design of reinforced columns apply to buildings of any number of stories in height. This is of interest, for the reason that some American architects are still averse to more than a limited application of reinforced concrete to building construction.

The report sets forth certain provisions which govern the design and construction of this class of work in substantial accord with similar provisions in force in the larger cities of this country, although some features are perhaps less extended and vary to some extent from corresponding provisions of American practice. The opening paragraph, however, is one which every engineer or other interested agent will indorse without qualification, viz: That the use of reinforced concrete has now become so general "in building and engineering construction, that a general agreement on the essential requirements of good work is desirable." If there is any one feature of reinforced concrete work imperatively needed at present in this country it is a body of uniform regulations designed to secure an excellent quality of well-built structures and so avoid the accidents which have been due to ignorance and indifference to suitable structural procedures. Reinforced concrete work needs, first, competent engineering design, and then intelligence and effective supervision to secure good materials and well considered structural processes. The accidents in reinforced concrete work which have taken place during the past two or three years in the United States and have thrown doubt upon the attainable excellence of this class of work are without any other cause than ignorance, incompetence or some sinister reason. Reinforced concrete is precisely like any other excellent building material in that it must be made and put in place under suitable specifications supplemented by competent design and supervision. One of the most commendable characteristics of the report of the committee is the recognition of these simple fundamental principles.

The proposals and specifications as to materials, as well as the practical instructions for actual fabrication of work, are all, in the main, well considered and adapted to secure the ends desired, although a few minor matters will, it is probable, be modified, by more extended experience. In this category is the provision that "work should not be carried on when the temperature is below 45 degrees Fahr." Experience during the unusually severe weather of last winter in New York city in constructing some of the heaviest and best reinforced concrete work ever built demonstrated conclusively that simple and effective measures for the protection of reinforced concrete during fabrication, including the use of enclosing canvas and salamanders, make it perfectly practicable to carry on this class of construction with the best results, with little or no interruption during the severest weather of a New York winter. It is also probable that further directions and provisions for the centers, or forms, and for their use will be set forth after more extended experience; to secure reduced expense, ease of removal and re-erection and general efficiency in this part of the work.

That division of the report relating to methods of calculation is especially worthy of commendation, although here also there seems to be some lack of recognition of what has been done in the United States in reinforced concrete construction. Within the past year the ratio of the coefficients of elasticity of steel and concrete has often been taken as fifteen rather than twelve, which is frequently employed here. The usual neglect of the tensile resistance of concrete is recommended and the straight-line law of the variation of intensity of stress in the concrete beam is adopted rather than any law, such as the parabolic represented by a curve. While the curved relation is used by a good many engineers, the general belief seems to be that the straight-line relation is as good for all practical purposes as the other, and is more easy to use. It is an open question, however, which can be definitely settled only when more experimental results are available than we now have, and even then the choice will probably be governed largely by the temperament of the individual engineer, as is the case to-day with the Gordon and straight-line column formulas.

The methods of calculation, relating to columns, appear to be set forth without knowledge of the most advanced reinforced concrete column design. The Considère type of column alone is considered, with its extremely light longitudinal rods which are considered by some engineers to be actual elements of weakness, although this weakness is supposed to be cured, by the wire or other banding. This column can never be satisfactory for use in the highest buildings. The type of column used in the McGraw building in New York, with its self-supporting steel column enveloping the concrete, is admirably adapted to any height of building whatever, and to the strongest and best possible connections for floor beams and girders. Such a column fully justifies 750 pounds per square inch on the concrete instead of 500 pounds stated in the report.

In spite of a few secondary considerations of this character, the report as a whole is well calculated to secure satisfactory results in this field of construction, wherever its recommendations are efficiently enforced.

State Ownership of Water Powers.

The Fuller bill recently signed by Gov. Hughes is likely to have an important bearing on the great unused water-powers of the Adirondack regions, for under this measure the State Water Supply Commission is empowered to collect full information regarding the water powers of the State and to devise plans for their development under State ownership and control.

The Adirondack region has many possibilities in the way of hydraulic development, and already several projects have been put on foot for the construction of power transmission plants in that region. Were these simply projects relating merely to the utilization of the streams in the ordinary way, probably they would have attracted little attention and would not have aroused any sentiment in favor of State control. In point of fact, the greatest possibilities in the Adirondacks are believed to lie in large developments with elaborate storage systems requiring very extensive hydraulic works and, possibly the diversion of considerable streams. Under these circumstances, the public may be deeply concerned in the projects and a safeguarding of the public interest becomes doubly necessary. It is certainly necessary to develop the hydraulic resources of the State to the fullest and so develop them that the best result possible shall be produced. To this end the proposed critical examination of the resources of the Adirondacks is a necessary preliminary. With the data once fully in hand it will be possible to carry out the utilization of the powers on a consistent plan and to the fullest extent.

Just how far actual development by the State will prove practicable or desirable it is impossible now to tell. It is possible that the State could successfully carry out the hydraulic work and lease the developed powers to transmission companies which would undertake the work of distribution, or the powers might be leased in their crude state with a provision by which the lessee should carry out the development in accordance with the lines laid out by the State. It is unlikely that the State would wish to undertake the full development and distribution, or that it would be desirable for it so to do. That these vast water powers are steadily assuming greater and greater importance is true, and the increasing cost of fuel will make them even more necessary in the future, so it is highly desirable that those which now remain unutilized should be developed in a systematic way. The aggregate result under a state power that can obtain from any system of water-courses depends in a large measure upon the skill with which the hydraulic work is planned, and if planned on a large scale after thorough investigation the final result will be vastly more satisfactory than if the development is carried on piece-meal by independent organizations.

The Engineering Record therefore believes that the fundamental principle of the Fuller bill is a thoroughly good one, and while it would dislike to see the State embark on public enterprises of an intricate character, it is certain that the State and its people will profit from a careful and intelligent exploitation of these water privileges. If it proceeds somewhat slowly, so much the better, for each year increases the resources of power transmission and renders development on a large scale and with a broad view of the future, the easier.

The Subjugation of the Ludlow Reservoir.

For many years the water of the Ludlow reservoir at Springfield, Mass., has had a most notorious reputation. It has been the subject of many investigations and its evil character has been laid bare in all American books on water supply which make any claim to thoroughness. The reservoir has stood forth from others as an unequaled cultivator of odors that rival the aroma of a fertilizer plant on a hot, moist day. The Water Board of Springfield has never enjoyed the distinction which ownership of this famous basin thrust upon them, and so, from time to time, they have asked various engineers and biologists how to make the reservoir behave as it was intended to. The Board has been accumulating this advice for many years, and has received all kinds of suggestions, ranking from physicking the water with germicides to treatment by repeated filtration. In the counsel of many lies wisdom, we are told, but the counsel in this case was too varied for the Board to sift, and so it eventually placed the burden on Messrs. Hazen and Whipple, the New York consulting engineering firm, which was engaged in preparing plans for an additional water supply for the city. A temporary additional supply was greatly needed pending the completion of the new works, which would not occur for several years, and the engineers naturally turned at once to the Ludlow supply, which is objectionable only on account of its offensive character at certain seasons. They have fortunately been able to construct works which have rendered this water suitable for city uses, and their success is a real engineering achievement.

The Ludlow reservoir was made by building two dams across valleys, thereby flooding a peat swamp with water to an average depth of perhaps 12 ft. A considerable proportion of the watershed is swampy. Ever since it was put in service thirty years ago the water has suffered during the summer from growths of micro-organisms. Anabæna has been the most abundant and best known of these, but probably many others have contributed to the tastes and odors, which have made this reservoir the most notorious in this respect of any reservoir in the United States. Possibly some reservoirs are occasionally more malodorous, but they are by no means so well known as this, which has generally been considered as the worst chronic offender in the country. The experiments that had been made on the purification of this water were all based on the use of continuous filtration, with aeration at different stages of the process. Two such filtrations in the experiments had sufficed entirely to remove the tastes and odors. One filtration with suitable aeration had usually sufficed to do this, but had proved wholly incapable of treating the water when the growths of organisms were at their height.

The idea suggested itself that, as the organic matter in the water was in a readily decomposable state and chemically was much like the organic matter in sewage, the system of purification which had given the best results in purifying sewage in Massachusetts might also be applicable to this water. The temporary plant designed was, therefore, in all its essential features, a sewage purification plant, in other words, intermittent filtration through coarse sand was used. By this method of filtration the water is aerated, not only before and after filtration, but during the whole process. The whole filtering material is drained once each day and its pores become filled with air, and this air, which is only partially displaced when the water is applied to the sand, serves to effect an additional aeration in the sand itself while the filtration is taking place.

It was expected when the plant was built that the quality of the water would be materially improved by it. It was not expected that complete removal of tastes and odors would be secured when the growths in the reservoir were strongest. At the same time it was recognized that the results to be obtained were more or less uncertain, for the process had never been adequately tested in treating a water of this character. The plant was put in service July 6, 1906, and served to remove the tastes and odors fully during that summer, although the growths in the raw water, for some reason, were not as great during this period as they had frequently been in previous years. The season of 1907 opened with a growth of uroglena as strong as had been previously observed in the reservoir, and this was immediately followed by a strong growth of anabæna, the most troublesome of all the organisms that have grown in this reservoir. Up to the present time the tastes and odors have been removed in an entirely satisfactory manner. The accomplishment of this result is probably due fully as much to the care and intelligence with which the filter has been operated by Mr. E. E. Lochridge, engineer of the Water Board, as to its design. Certainly the remarkable results that have been obtained could not have been secured with anything but the most skillful supervision. In connection with the removal of the tastes and odors there is a striking reduction of color which is most interesting. This reduction in color seems to be due to the coagulating effect of the iron, which is present in the ferrous state in the reservoir water at the times of growths and is precipitated by the aeration and filtration of the water, thereby accomplishing results which certainly could not be reached were it not for the iron.

The cost of the filter complete was about $50,000. It should be stated, however, that many parts were built in a temporary way and without reserve, and that it would not be possible to build a permanent plant of this type, with duplicate parts, for this sum. The quantity of water treated is 10,000,000 or 12,000,000 gal. per day. The Ludlow reservoir is able to supply this amount in a wet year or an average year, but would be quite incapable of maintaining the present rate of draft in a dry year; and for this reason the additional works now authorized would be necessary, even though the treatment of the Ludlow reservoir should prove in all respects to be feasible.

This experience teaches an important lesson, for it shows very clearly the practical value of the knowledge of the characteristics of water and the methods of purifying it which have been acquired by those who have been makilng a specialty of the subject. The progress of late has been extraordinary, and uncertainty concerning the nature and cause of many phenomena has given way to reasonably complete knowledge. But it is important to bear in mind that this increasing knowledge brings complications with it and is difficult to apply. The Water Board that attempts to determine how to improve the quality of a supply from what information it can gather from books will be very sorry that it assumed the role of a specialist, while the superintendent who carries out works for water purification without securing the advice of competent experts is not likely to obtain the best possible results at the minimum of expense. The purification of water and sewage are not simple problems, but are complicated by many conditions of different degrees of importance, which only specialists can appraise accurately.

Notes and Comments.

The Architectoral Development of Suburban Property will be investigated by a committee of the Royal Institute of British Architects consisting of Mr. T. E. Collcutt, president, Sir Aston Webb and Messrs. John Belcher, Paul Waterhouse, John W. Simpson, W. E. Riley, Leonard Stokes, Reginald Bromfield, and Prof. Beresford Pike. The purpose of the committee is to suggest lines on which a scheme can be prepared for the expansion of suburbs of large towns on a rational plan. This is a topic of much importance in the neighborhood of many large American cities, where the rate of growth is even faster than it is in the vicinity of European cities. Many suburbs suffer from a lack of proper planning when they were first started or before they began to develop rapidly. It is often considered that the control of the growth of a suburb is impracticable, but experience indicates that where attention is paid to the prospective development of transportation facilities and to the fitness of a locality for the homes of people of different classes, it is possible to guide the development quite closely. Just what lines the committee of the Royal Institute will follow is now unknown, but it goes without saying that all suggestions from a body of such eminent architects will prove valuable, although they may be impracticable for many suburbs. Too many committees of a somewhat similar nature have seen fit to recommend schemes of development which cannot be adopted on account of their costly nature or lack of fitness for the community for which they were intended.

An Anomalous Road Situation exists between Newark and Jersey City, respectively, the sixteenth and seventeenth cities of the United States in population, which are about 7 miles apart. Newark is noted for the great variety of its manufactures and has a heavy trade with most places in the vicinity. Jersey City, on the Hudson River water front, is also a manufacturing place, and the relations between the two cities would naturally be quite close. They are separated, however, by a stretch of marsh, and although several railways have been built across it, there are but two roads connecting the two cities, and both are in such a condition that travel over them is an unpleasant task. One of these roads is a plank affair, which may have been in fair condition years ago but now has its planks so loose that they are positively dangerous. A line of trolley cars runs along this road and their presence does not by any means improve the character of the highway. The other road is an alleged macadam affair, but its condition is such that nobody uses it who can avoid doing so. The importance of the lack of good roads in this district is so great that before long their improvement will undoubtedly be undertaken. At the present time the meadow land is regarded as the future site of many large industrial establishments, and a number of them have already been erected on its borders, notably the large plant of the International Pump Co. Many people are interested in developing this territory, in a general way, but it seems to be overlooked by most of them that until roads are constructed across it which are fit for use by both light and heavy teams, it will hardly be practical to get many industries to settle in the vicinity. But with good roads connecting Newark and Jersey City, and with water front facilities such as can be readily furnished, it does not seem improbable that the dreams of a great industrial center on the Jersey meadows will be at least partially fulfilled.

The Philadelphia Filtration Contracts held by the McNichol firm have probably attracted more attention than any contracts for public work in this country for some time, owing to the attempt of the authorities of Philadelphia to have them annulled on the ground of fraud. A few years ago all sorts of assertions were made concerning the character of the work and the favoritism shown to this firm. When work was stopped a large sum was due the contractors as deferred payments, and after heated controversy and an unsuccessful attempt to show that a former chief of the bureau of filtration was negligent in the discharge of his duties, or worse, the whole matter was finally left to an arbitrator. On July 22 the latter decided that the city was indebted to the firm for more than $2,000,000 and the sum awarded was immediately paid over by the city to the contractors. The arbitrator also found that while one of the members of the firm was a member of the city councils he received about $51,000 as his part of the profit on the contracts, and this sum the arbitrator has directed him to return to the city. It is fortunate that the matter has at last been settled, for the controversy has resulted in great delay in the completion of much needed works for the purification and extension of the Philadelphia water supply. During the progress of the construction, the work was visited by many engineers, and this journal has yet to learn from any of them that the character of the work was not fully up to the average of good municipal construction. It is true, however, that the contracts were generally taken at a very high figure, as such work goes, and it is possible that better prices might have been attained had some of the conditions attending the award of the contract been different. So far as the engineering work and the actual construction are concerned, however, it is hardly probable that were the work to be placed under contract to-day, with all the knowledge gained in the interim, the workmanship would have been much different or the prices much lower.

The Smoke Nuisance was the subject of a very important recent decision by the New York Court of Appeals in McCarty *v.* Natural Carbonic Gas Co., 81 N. E. Rep., 549. The question the court has to decide was: in a country district suitable for country homes, does the use of soft coal in a factory so situated that thick black smoke therefrom, great in volume and dense in quality, envelops and discolors a neighboring dwelling house, causing much discomfort and some financial loss to the occupants, constitute a nuisance, when such use of soft coal is not necessary for the practical running of the plant and is not a reasonable use of the manufacturer's property? The court decided that while the defendant's business was lawful and not of itself a nuisance, it was a nuisance as conducted, although a neighboring plant where anthracite coal was burned was not one. It was therefore ordered that the company must either burn hard coal or make such alterations in its plant that soft coal can be burned without causing offense. This opinion is particularly important because it does not refer to a smoky plant in a city, but to one in the country, where the house of the plaintiff is 840 ft. distant. It therefore establishes the rule throughout the entire State that no boiler plant may be so conducted as to be a nuisance without being subject to a permanent injunction until it is rendered practically smokeless. Whether it is a nuisance or not must be determined from all the facts in each case, and this is likely to cause considerable controversy, but the decision as a whole is nevertheless of much technical importance. It is fortunate that the upper court did not uphold the decision of the trial court, which forbade the use of soft coal under all conditions. The time is at hand when soft coal must be used far more extensively than at present, for the supplies of anthracite are running short except from collieries which it is expensive to work. There is no reason why soft coal should not be used except the practically universal lack of knowledge of American people concerning the way to burn it without producing dense smoke. It is sometimes said that smoke is inevitable where soft coal is used; the complete ignorance shown by those who make such a statement can be readily demonstrated by a visit to any large European city, where soft coal will be found in general use but without causing any greater obscurity of the atmosphere than in New York City to-day.

A Wholly Unjust Requirement is contained in the proposed terms of the contracts for some of the New York Barge Canal improvements, which, it is safe to say, the eminent lawyer who is now Governor of the State would alter immediately if it were brought to his attention. Section 29 of the proposed contract for some improvements now being advertised reads as follows: "The State Engineer shall between the first and fifteenth days of each month make and file with the Superintendent of Public Works an estimate of the amount, character and quality of the work done and of material which has been actually put in place in accordance with the terms and conditions of this contract during the preceding month and compute the value thereof. The Superintendent of Public Works *may* within fifteen days thereafter, at his office in the City of Albany, N. Y., pay to the contractor from the money which shall have been appropriated for that purpose a sum not to exceed ninety per cent. of the value of the work performed and material furnished as so certified by the Engineer—retaining not less than ten per cent thereof until the contract shall have been completed and approved by the State Engineer and Superintendent of Public Works." Attention is called to the use of the word "may," as it makes the contract a mere gamble and possibly destroys its legality for want of consideration. As the clause now stands, whether or not the contractor gets his money depends on the whim of the Superintendent of Public Works, as there is no law to compel him to pay, nor any contract provision, and only a suit in equity, assuming one to be possible, would give the contractor relief from an official who was disposed to withhold money from a contractor until the latter had seen the right people. This journal does not believe that any of the people now in office would make any improper use of this peculiar wording of Section 29, but it is very strongly of the opinion that no contractor is justified in signing a contract involving large sums of money which does not protect him in the very vital matter of payments in a better manner than that above quoted. There has been so much scandal and so much wrangling over canal work in New York, that such a palpable opportunity for graft as this clause offers should be immediately done away with.

The Strength of a Dump Cart is something few people have ever had an occasion to determine carefully, and for this reason some tests made by Prof. W. K. Hatt, in the laboratory of Purdue University are decidedly interesting. They were made on a stock cart built by the Troy Wagon Works Co., and rated at a safe capacity of 4½ tons. The purpose of the tests was to show just what resistance could be expected from such a cart under the most adverse conditions of loading. The first test was made by filling the body with sand and applying a heavy load on top of it with a testing machine. Failure did not occur until 36¼ tons had been applied, at which point the body gave way, but the running gear was uninjured; this is equivalent to a factor of safety of about 8½. The second test was to show the resistance of the rear wheels to the strain brought on them when the wagon rests on a side hill parallel to the slope, the latter being just below the inclination, 31 deg., which will cause the fully loaded cart to overturn. The theoretical force acting at right angles to the wheel rim under such conditions is 2,680 lb., while the test showed that the wheel had a resistance of 5,500 lb. to such a load, equivalent to a factor of safety of a little over 2. Inasmuch as no teamster ever drives a loaded wagon on a side slope as steep as this, it is evident that the actual factor of safety is largely in excess of that mentioned. The third test was to ascertain the resistance of the rear wheels to the strain that occurs when the wheel is caught in a rut and the horses attempt to turn it out of this rut. Prof. Hatt figured that theoretically the maximum strain which would be produced under such conditions was about 7,600 ft.-lb., while the wheel which was tested developed a resistance equivalent to 13,080 ft.-lb. This gives a factor of safety of 1¾, but as it will rarely happen that a single wheel is caught in a rut and has to withstand the whole wrenching of turning out, it seems likely that the actual factor is considerably higher. The fourth test was to determine the strength of the rear axles under actual load conditions, which was found to be 31,000 lb. Full details of the tests and results are given in a little pamphlet issued by the builders of the carts, and are instructive as showing the real strength of such wagons. They also show how the modern testing laboratory can be utilized to furnish definite information concerning appliances that, until recently, were considered to be beyond the range of experimental examination.

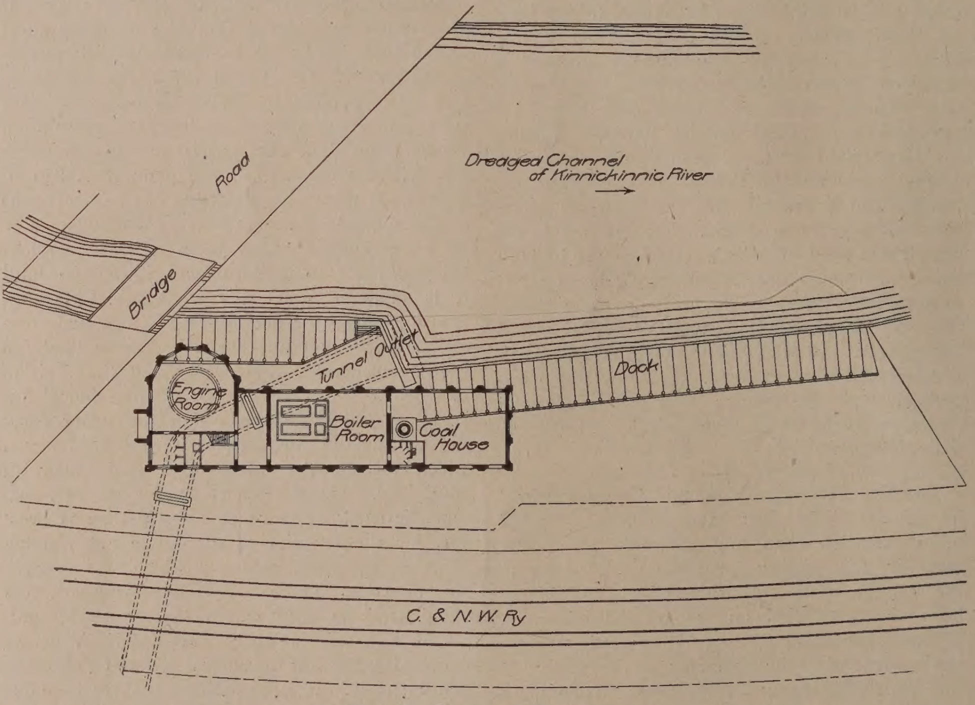
THE KINNICKINNIC RIVER FLUSHING TUNNEL AND PUMPING STATION, MILWAUKEE, WIS.

The Kinnickinnic River in Milwaukee, Wis., rises about 10 miles southwest of the central part of the city and empties into the Milwaukee River at a point half a mile from the mouth of that stream in Lake Michigan. The mouth of the Milwaukee River is a little to the south of the central business district of the city, the river running northwesterly for nearly half a mile from its mouth, and then turning to the north, which general direction it follows to beyond the outskirts of the city. The original portion of the city, and what is now its most congested sections, lies between the lake and the Milwaukee River, and to the west of the latter. The area along the Kinnickinnic River just south of the central business district is largely covered with factories, while farther out are residence sections, which are comparatively new. The Menominee River flows east and west through the city and also joins the Milwaukee River at the point where the latter turns to the north. The land on both sides of the Menominee River is fully occupied from its junction with the Milwaukee River to the city limits, a distance of about two miles, with factories and coal and steamship docks.

The sewerage system of Milwaukee is on the combined plan, practically all the sewers having their outlets in one of the three rivers. All three streams have comparatively small watersheds, which are of such nature that during dry weather the flow in them is slight. The Milwaukee River has an average width of 200 ft. and a depth of 20 ft. for about 3 miles from its mouth; the Kinnickinnic River is also 200 ft. wide and 20 ft. deep for nearly 2 miles from its mouth, and its channel is being dredged to that cross-section for one-half mile farther. The large cross-section of the Milwaukee River, the small volume of water flowing in it during eight to ten months of the year and the great amount of sewage tributary to it, long ago rendered the stream very offensive for all but two or three months in the year. In order to relieve the situation, a 12-ft. tunnel, 2,500 ft. long, was built in 1888 from an intake on the shore of Lake Michigan to the river at a point just downstream from a dam which is about 1½ miles south of the northern limits of the city. All of the sewage above the dam is intercepted and carried below the mouth of the tunnel. A 14-ft. screw-pump, placed in this tunnel near the lake, gives a head of 3 ft. to the water in the tunnel, which is sufficient to cause a large enough flow through the tunnel from the lake to flush the river. This pump is driven by a vertical tandem-compound steam engine in a pumping staiton near the lake. The water supplied through this flushing tunnel has kept the river in good condition at all times since it was placed in service over 19 years ago.

When the Milwaukee River flushing tunnel and pumping station were built, the areas along the Kinnickinnic River were sparsely covered with buildings, and the old channel of the latter river had not been dredged to its present cross-section. Since then these areas have become quite congested and the river has been widened, with the result that the pollution of the stream has been greatly increased and the nuisance caused by this pollution has been correspondingly aggravated, until in the last few years some means of relieving the situation became an imperative necessity. A flushing tunnel, 12 ft. in diameter and 7,182 ft. long has accordingly been built from Lake Michigan to a point on the river, 2½ miles from the mouth of the latter. A pump similar to the one in the Milwaukee River tunnel was placed in this tunnel at the river, and is driven by an engine in a pumping station built over the outlet end of the tunnel. The river will be dredged to the standard width of 200 ft. and depth of 20 ft. from the lake to this pumping station, and as it is only 20 to 30 ft. wide above the station no trouble from pollution in this portion of it is anticipated.

The intake at the lake, from which the tunnel starts, consists of two parallel, rock-filled pile piers which are 60 ft. apart and extend 385 ft. into the lake from the shore line, the channel between the piers having been dredged to a depth of 16 ft. As practically all heavy storms on the lake and most of the floating ice come from the northeast the intake has been built to provide against any difficulties which may arise from this condition. The pier on the south side extends 300 ft. from the shore line, an opening 75 ft. wide being left between it and the end of the intake; the pier on the north side is carried 75 ft. farther out, and has a section, 80 ft. long, at right angles to it at the end, which section is across the end of the intake channel and protects the opening along the south side of the intake. The corner between the end and north side piers is reinforced with a diagonal pier on the inside and is riprapped on the outside with heavy stone for a width of 32 ft. along the end and for 50 ft. from the corner along the side The two parallel side piers converge at the inshore end, and in a distance of 85 ft. from the shore line the space between them is reduced to a width of 12 ft. A short length of concrete conduit connects the end of the intake with the tunnel proper, the cross-section of this concrete conduit being changed from square to circular from the outer to the inner end fo it.



Plan of Pumping Station.

The piers of the intake consist of two rows of round piles which are 10 ft. apart, outside to outside of rows. The piles in the outer row of each pier are 18 in., and those in the inner row 36 in. apart on centers. The two rows of piles in each pier are tied together at the water line by 1¼-in. rods spaced 3 ft. apart, these rods being anchored to 8x12-in. waling timbers. A row of 2x12-in. triple-lap sheeting is driven along the inside of each row of piling to hold the stone filling in place. The piers are also floored over 5 ft. above the water level.

Floating debris and ice will be prevented from entering the tunnel through the intake by a heavy iron rack across the latter near the mouth of the tunnel. This rack is 37½ ft. across the face and is built in sections each 5 ft. wide and 19½ ft. high, the top of the rack extending 2 ft. above the water level. Each section consists of a ¾x6-in. plate frame having vertical 1-in. rods spaced 4 in. apart on centers between these plates. These sections slide in 8-in. I-beams placed vertically, so they can be removed and repaired readily.

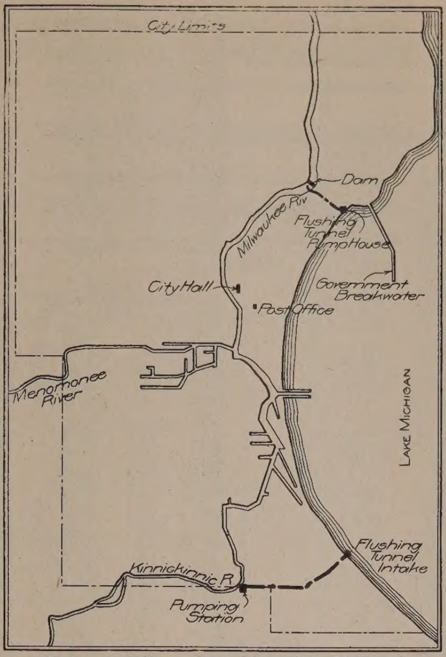
The tunnel was built under city streets for almost its entire length. The invert of the tunnel is 16 ft. below Milwaukee city datum, which is approximately the average water level in Lake Michigan, at the inlet end, and 20 ft. below that level at the outlet end in the river. The excavation was all carried on in tunnel, with the exception of a short length of about 450 ft. where an old creek valley was crossed in open trench. The cover over the top of the tunnel varies from 5 to 80 ft. The tunneling was handled from six shafts, and on the whole, no difficulties were encountered while it was in progress, as the work was practically all through clay, or sandy clay, which for the most part could be shored with light timbering. Quicksand was encountered for a short stretch, however, and some trouble was occasioned in building this section of the tunnel.

The tunnel is lined with four rings of Milwaukee sewer brick laid in Milwaukee Portland cement mortar. Manholes for entering the tunnel are provided at each end of the latter. A 12-ft. cast-iron sluice gate is placed in the tunnel at the inlet end. A gate of the same size and type is also placed in the tunnel on each side of the pump at the river.

The pumping station was located at the river end of the tunnel instead of at the lake end, as is the pumping station for the Milwaukee River tunnel because a better site could be had at the river. The station is immediately along the bank of the river, between the latter and the Madison division of the Chicago & Northwestern Ry. and faces on a public highway, so the best of transportation facilities are available.

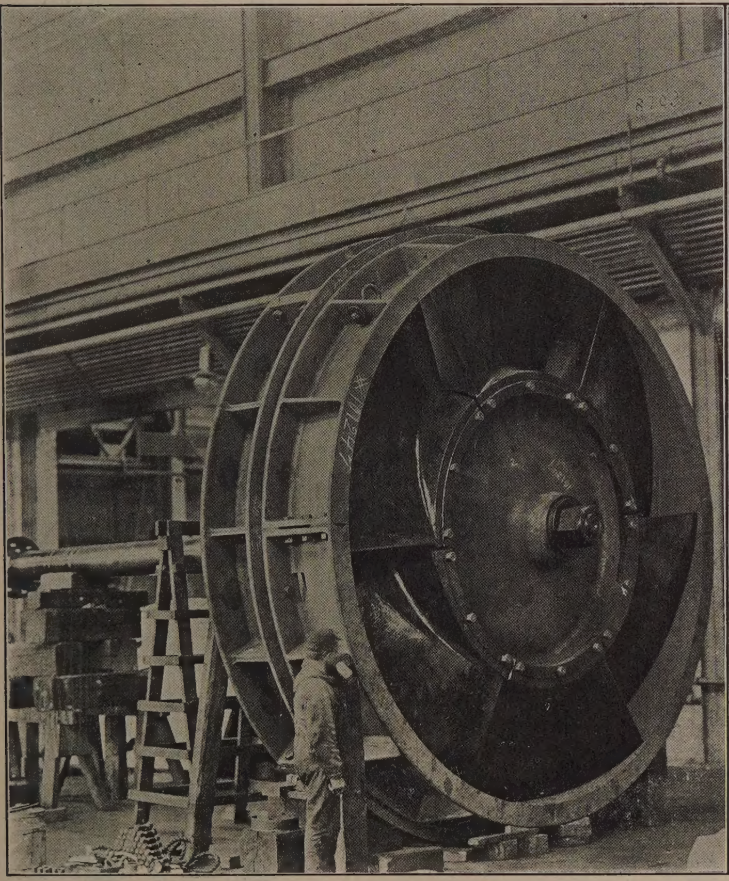
The building has a concrete substructure carrying a red brick superstructure trimmed with Bedford sandstone. The roof of the building is of 4-in. concrete slab, reinforced with expanded metal and carried by steel trusses resting on the side walls. The concrete slabs are covered by green interlocking terra-cotta tile, which are laid in roofers' cement and have a glazed surface finish.

The general arrangement of the station and its surroundings is shown in an accompanying illustration. The station building is 34x165 ft. in plan in the clear, the front end being made wider to accommodate the engine which drives the pumps in the tunnel. The building is divided into an engine room, an engineer's office and storage room at the front, then a repair shop, boiler room and coal storage room, in order.

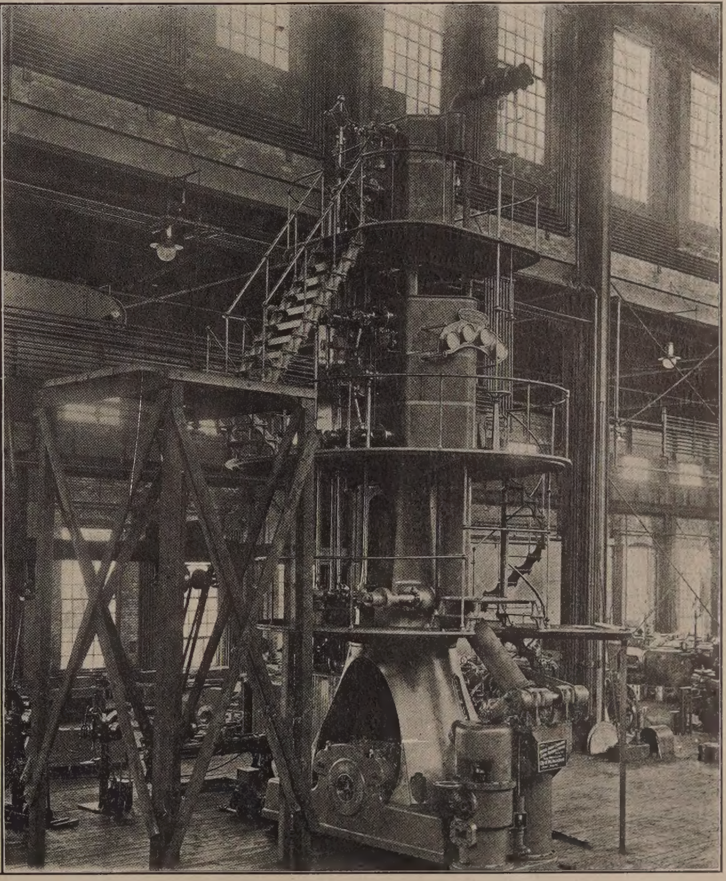


Map of Milwaukee Showing Tunnel.

The screw pump and the engine which drives it are of the same type and generally the same arrangement as the pump and engine of the Milwaukee River flushing tunnel. The pump has a wheel 12.5 ft. in diameter made up with six impeller blades attached to a 12-in. shaft. This wheel revolves in a casing set in the tunnel lining. A cone, 6 ft. in diameter at the base, is placed concentric with the wheel on the side from which water approaches the latter and directs the flow on the blades. A second casing placed just beyond the wheel contains stationary deflector blades which reduce the swirling motion given to the water by the wheel.



Wheel of 12.5-Ft. Screw Pump.



Pump Engine Set Up in Shop.

The 12-in. shaft on which the wheel is mounted is carried by an outboard bearing in the center of the second casing, where it is supported by the reflector blades. The pull on the shaft is taken up by a thrust bearing of the marine type, which is placed inside the engine pit. The shaft is 32 ft. long and extends through a stuffing box in the side of the engine pit and is direct-connected to the crank disk of the engine.

The engine is of the vertical tandem-compound condensing type with a Corliss valve gear, and is practically a marine engine without the reversing gear. It has sufficient capacity when supplied with steam at 140 lb. pressure, and running at 55 r.p.m., to drive the pump so the latter will raise 30,000 cu. ft. of water per minute against a head of 3½ ft. The pump for the jet condenser, which is supplied with water from the tunnel, and all other auxiliaries are driven by rocker arms attached to the cross-head of the engine.

Steam is supplied by two 72-in. by 18-ft. return tubular boilers equipped with Hawley down-draft furnaces and Foster superheaters. The furnaces are connected to a Custodis radial brick stack, 135 ft. high. The superheaters supply steam to the engine at a temperature of 100° Fahr. above that of saturated steam.

A 25-kw. direct-current generator direct-connected to a De Laval steam turbine furnishes power for lighting.

The large sluice gate valves on each side of the pump permit the latter to be shut off from the river and from the tunnel. The valve at the lake also permits the tunnel to be shut off from the lake. These valves are all of the same general design. The two at the pumping station were built by the Coffin Valve Co., and the third by the Wm. Bayley Co. The valve disks are cast-iron. They carry on both sides at their circumference, a turned and planed brass ring, each of which seats against a brass ring carried by the valve box. A 2-in. pipe extends from the surface to a connection in the valve box so the sediment may be flushed out of the bottom of the latter. Each disk has two 3-in. steel stems, one on each side, which rise in channels in the sides of the valve chamber. These stems are each geared to a worm on a horizontal shaft on an operating stand over the chamber. This shaft is fitted with a windlass crank at each end and will be turned by hand, as experience with the original flushing tunnel has shown that the gates are rarely moved. 2.5-ft. sluice gate operated from the surface through a non-rising stem is placed on each of the large valve disks, and is used to equalize the pressure on both sides of the latter.

The station was designed and built under the direction of Mr. Chas. J. Poetsch, M. Am. Soc. C. E., city engineer of Milwaukee. Mr. B. W. Perrigo, assistant city engineer, was immediately in charge of the design and construction. The pump and engine in the station were built by the Allis-Chalmers Co., of Milwaukee, the Edward P. Allis Co., one of the constituent companies of the Allis-Chalmers Co., having built the pump and engine for the pumping station of the Milwaukee River flushing tunnel.

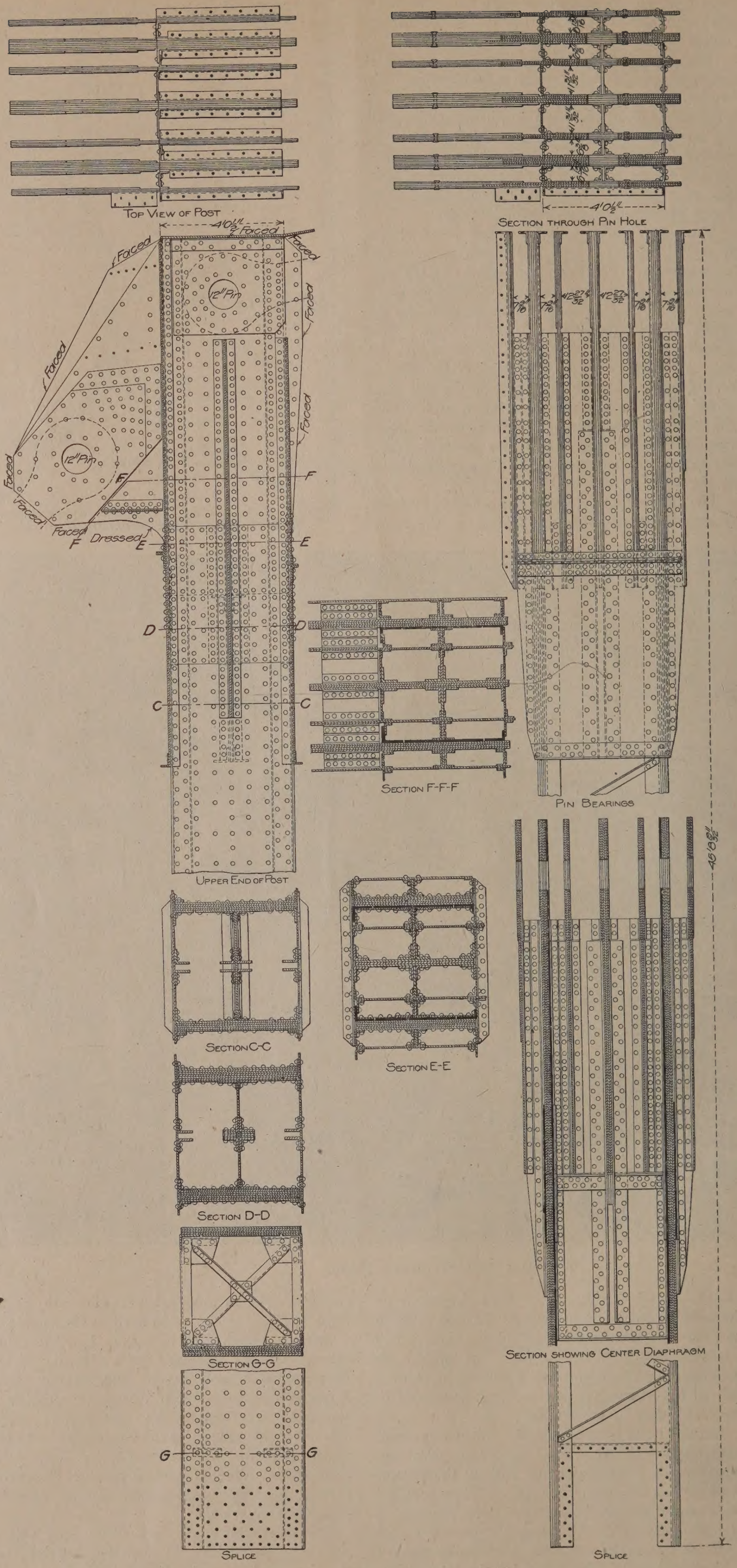
Fire-Killed Timber is being used more extensively each year in the West for railroad ties, and where tried in the same track with ties cut green, has been found to be as good as the latter. Despite the fact that dead timber is often regarded as unsound there are many tracts of it, killed by fire 15 or 20 years ago, that are still sound. The strength is not impaired, and the durability is often increased. The Forest Service is selling such timber on its reserve.

Widening Blackfriars Bridge, London.

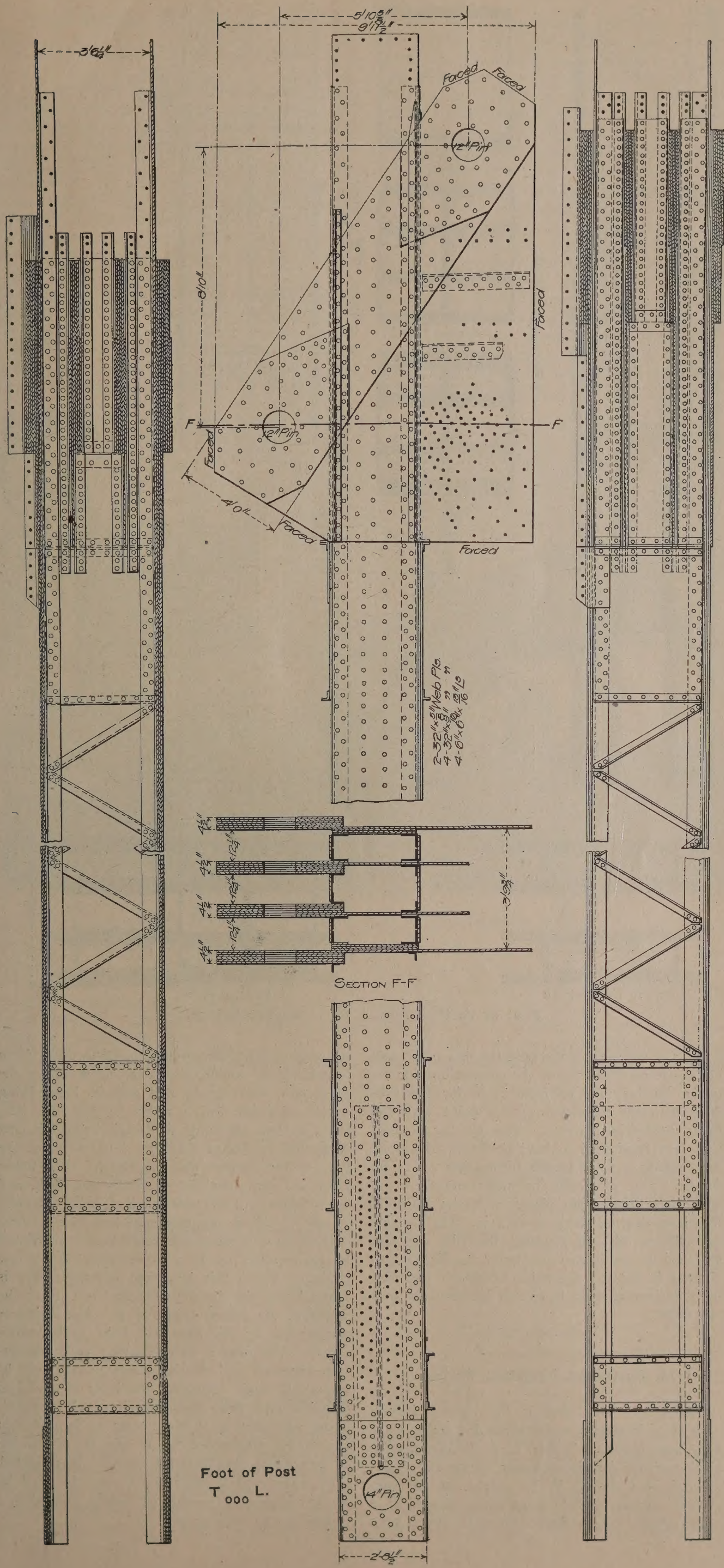
Improvements estimated to cost about $1,000,000 are now in progress on the Blackfriars Bridge across the Thames, at London, and include the extension of the upstream ends of the piers and abutments to receive three new lines of steel arch ribs 10 ft. apart increasing the width of the superstructure to 105 ft., which will make it the widest bridge across the Thames. Pile platforms at a level of about 5 ft. above high water have been built to enclose the upstream ends of the piers and to support during construction the steel caissons and cofferdams in which the extensions of the substructure will be built by the pneumatic process. On these platforms the permanent steel caissons are riveted up complete to a total height of about 13 ft., after which each of them is suspended from four overhead hydraulic jacks seated at the ends of two pairs of steel girders supported on timber trestles. Brackets bolted to the caissons are pin-connected to the lower ends of suspension links, each of which is formed of alternate single and double flat steel bars 10 ft. long, pin-connected together for convenience in the insertion of additional lengths as the caisson descends. The upper length passes through the hollow plunger of the hydraulic jack and engages a pin bearing on the saddle of the jack. The slotted pin holes in the links are 12 in. apart to correspond with the stroke of the jack. As the caisson descends, the successive courses of the steel cofferdam above it are built on, the shoe concreted, the caisson lowered to rest on the bottom of the river and the overhead girders and jacks removed. Air pressure will then be admitted and the caisson excavated to the required depth of about 27 ft. below low water, where it will be concreted and grouted and will be subjected to a test load before the superstructure is built on it.

Wooden cofferdams puddled with clay will be built to enclose the adjacent ends of the new caissons and of the old piers, enabling the end walls of the caissons and the adjacent masonry in the old piers to be removed and allowing the new masonry to be bonded with the old and additionally secured by a pair of steel trusses built into the masonry and serving to carry the skew-backs for the new arch ribs. Riveting and other work will be done by pneumatic tools operated by air from electrically driven compressors and all hoisting engines will also be driven by electricity. The parliamentary plans were prepared by the late Sir Benjamin Baker and the work is in charge of Mr. Basil Mott and Mr. E. M. Wood. Sir Wm. Arrol & Co. are the general contractors and, according to "Engineering," the work is to be completed in three years with a penalty of $100 a day for all time in excess and an equal bonus to be given for time saved.

Technical Clubs among the employes of large engineering offices are among the most useful means of keeping men interested in their work and acquainted with the problems that arise in other departments than their own. They are generally encouraged by the officers of such companies on account of this good influence. The last to be organized is the Engineers' and Constructors' Club, which has been formed among the staff of Dodge & Day. Its object is to discuss subjects relating to engineering and construction, and to give all members the benefit of the experience gained by each in his particular line of work. During recent meetings papers have been presented and discussed on civil engineering preliminaries for an interurban trolley, electric welding, gas producers and internal combustion engines, and concrete piling, the discussions showing much interest in the subjects.



Upper Part of Vertical Post, UP_1 L, Quebec Bridge.



SECTION F-F

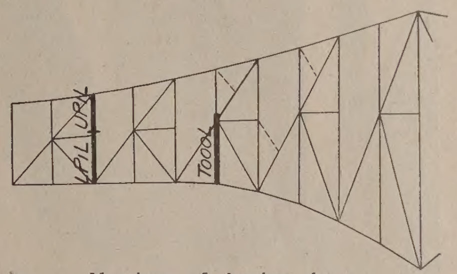
Foot of Post T 000 L.

The Quebec Bridge Superstructure Details; Part V.

Vertical Post P_1.—The dimensions and stresses of the vertical posts change rapidly toward the ends of the anchor arms. They are typical in post P_1, about 114 ft. long over all, which has a cross-section of 370 in. to provide for a uniform maximum stress of 5,365,000 lb. throughout. It is nearly 4 ft. sq. and has a rectangular cross-section made of two built channels 4 ft. deep. Each channel is made with five plates riveted together to make a solid web 3 3/16 in. thick and two 8x6x13/16-in. flange angles turned inward with their flanges latticed except at the ends of the posts with 3x3-in. diagonal angles.

The upper part of the post is 45 ft. 8 in. long over all and weighs about 120,000 lb. It differs from the upper part of post P4, in that it only has one pin for the top chord bars, all of which from both panels interlock on the same center line. The outside webs and three additional interior webs, making seven in all, are provided for the bearings of the top chord pins and are extended on one side to afford a connection for the diagonal eye bars which also have a 12-in. pin taking bearing in all seven webs. The webs are connected by a center transverse diaphragm and by two side diaphragms in the planes of the flange angles of the post.

The regular 4-ft. web plates are cut short and are extended to the upper ends of the post by special wide plates about 12 ft. long which are shop riveted to the continuous flange angles. The plates are reinforced to give pin bearings from 1¼ in. to 2⅞ in. long, and like the webs in the other similar members of the bridge they were assembled and shop riveted separately to form independent ribs with I-shaped cross-sections which were then shop riveted between the transverse plates of diaphragms and the pin holes were bored and counterbored to templates. A horizontal cover plate is bolted across the top of the post to exclude snow and rain.



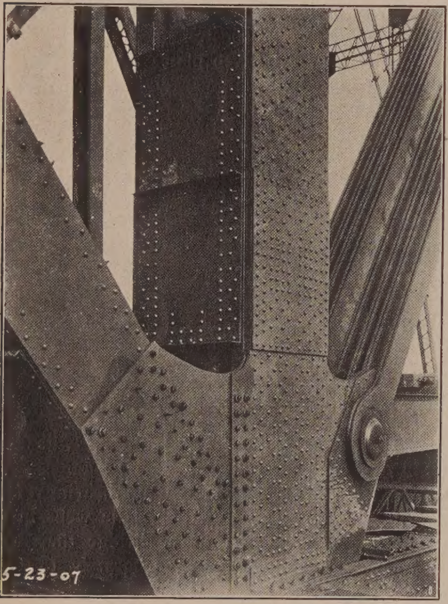
Members of Anchor Arm.

The lower part of post P_1 is 68 ft. 7½ in. long over all, and weighs about 150,000 lb. The cross-section is the same as that of the upper part and its bottom chord and diagonal connections closely resemble those described in a previous article for foot of post P4, but have much smaller dimensions. The main ribs and intermediate ribs are reinforced to total thicknesses of 5½ in., giving a combined length of bearing of 22 in. for the diagonal eye-bar pin. The holes for the chord pin bearing in the same webs are bored at a point where they are less heavily reinforced and have thicknesses of only 2⅞ in. and 3¼ in.

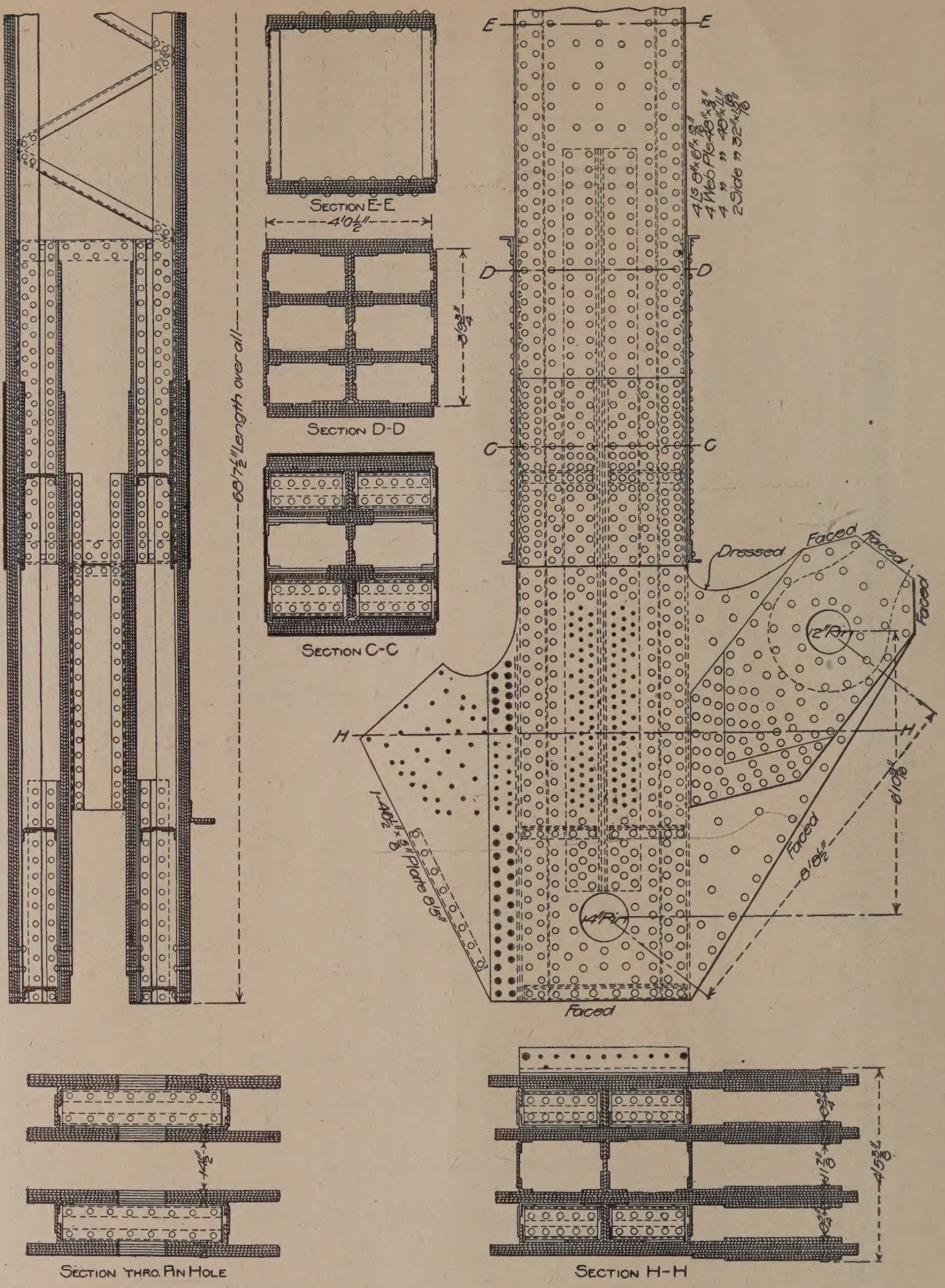
The center transverse diaphragm clears the upper flange of the lower chord and beyond it the two pairs of outside webs project in the spaces between the lower chord webs and are themselves stiffened by I-shaped diaphragms to make double jaws interlocking with the lower chord. The wide outer web plates are spliced to the regular 4-ft. web plates of the post channels with inside and outside shop-riveted cover plates, and the upper ends of the two inner web plates is coincident with the center of the splice and is stiffened by two horizontal transverse diaphragms. The center vertical transverse diaphragm is shop riveted between the post webs and extends about 8 ft. above the center of the web splices and nearly 13 ft. below it to he end of the post, but is slotted for a depth of 4½ ft. at the bottom to clear the center rib of the bottom chord.

The sub-verticals at intermediate panel points of the truss are compression members made in two or more sections each with riveted splices and pin connections to the top and bottom chords. A fair example is the post marked T000 between vertical posts 2 and 3 at about the middle part of the anchor arm. This member has a total stress of 58,000 lb. in the upper part and 1,307,000 lb. in the lower part, which is 72 ft. long over all, weighs 92,000 lb.; the upper and lower parts are each shipped separate and complete from the shop and field riveted at the splice just above the intersecting diagonal.

Like the main vertical posts this member has a rectangular cross-section made with two built channels having their flanges turned inward and latticed. Each channel has a total thickness of 1⅞ in. and is made with three 32-in. web plates riveted together, and two 6x6x13/16-in. flange angles. At the lower ends there are two 41x½-in. flange plates nearly 5 ft. long, which produce a closed rectangular cross-section and have a center transverse I-shaped diaphragm to make a rigid connection between the two webs and stiffen them to receive the floor beam connection on the inner face of the post which is made with 110 ⅞-in. field-driven rivets. The webs project beyond this diaphragm to form jaws engaging the lower chord pin betwen the center and outside webs of the chord.



Foot of Post, Quebec Bridge.



Foot of Vertical Post, L P_1 L, Quebec Bridge.

Just below its upper end this part of the post intersects the main diagonal member of the panel which consists of sixteen eye-bars made in two lengths and connected at this point. The large number of heavy pieces meeting here would require a long pin and develop difficult packing besides throwing the bars somewhat out of alignment if all were assembled on the same pin. To avoid this two pins are provided through opposite ends of a series of four oblique plates forming short links riveted to the post at the point of intersection so as to provide for the pins in opposite ends outside of the post flanges.

These links are riveted to the post webs and to two intermediate diaphragms, thus forming four longitudinal webs similar to those already described for the upper ends of the main vertical post. On one side of the post the two outer web plates are extended below the connections for the upper eye-bar pins to form jaws for the sub-diagonal strut connected at this point with 198 ⅞-in. field-driven rivets. The eye-bar connections are reinforced to have thickness of 4½ in. thus giving a total length of bearing of 14 in. for the 12-in. pins. At the upper end there are somewhat thinner pin plates, reducing the total length of bearing there to 12¼ in. On the side adjacent to the sub-diagonal the ribs are also stiffened by two horizontal transverse diaphragms about 2 ft. apart at the point where one end of a light horizontal strut is riveted between the outside ribs.

(To be continued.)

An Australian Irrigation Project.

The barren jack dam is the leading feature of a great irrigation undertaking for which plans have been prepared by Mr. L. A. B. Wade, principal engineer for rivers, water supply and drainage of New South Wales. It is to be constructed across the Murrumbidgee River, at a place where the catchment area is about 5,000 sq. miles. The dam will be 232 ft. high from foundation to coping, the latter 12 ft. above the maximum water level, and 910 ft. long, being curved upstream with a radius of 940½ ft. The cross section, according to "Engineering," is that suggested by Major Tulloch. The width of the base at the deepest place is 160 ft. The lower faces on both sides rise vertically for 20 ft. and the thickness of the dam then decreases rapidly to 145 ft. Then the upstream face has a batter of 1 in 20 and the downstream face 1 horizontal to 1½ vertical up to a point 60 ft. below the coping. Above this level the upstream face is vertical and the downstream face is curved, the width at the coping being 18 ft. The reservoir impounded by this dam will hold 33,380,000,000 cu. ft. The dam is to act merely as a regulating structure, and the impounded water will be let out through outlets in the body of the dam into the river-bed, down which it will flow for about 220 miles to a large weir so located that the water impounded by it can be discharged by gravity to the 6,500,000 acres to be irrigated. The water will be distributed over the land by a very extensive system of canals and ditches controlled by head gates.

Sewage-Disposal by Biological Processes.

Presented to the Engineering Conference of the Institution of Civil Engineers by John Duncan Watson.

An absolutely essential feature of a good scheme of sewage-purification should be an efficient method of eliminating solids without nuisance. At Birmingham this is done by mechanical precipitation and septic treatment. The elimination and removal of grit, etc. (50 per cent. water), costs 5*d*. per cubic yard. The elimination and removal of sludge (90 per cent. water) costs one-third of a penny per cubic yard. (Both figures are exclusive of the capital cost of tanks, etc.)

No matter by what method the tank-liquor is prepared for oxidation and nitrification on a biological filter, it is desirable that it should be rendered as free from suspended matter as possible. It is possible to reduce the suspended solids in septic liquor from 29.1 to 6.1 parts per 100,000 for the sum of 2*s*. per million gallons treated.

Upper Section of a Vertical Post on Car; Quebec Bridge.

The tank capable of effecting the above result had the Dortmund tank for its prototype, but it is essentially different, both as regards principle of construction and form.

The Birmingham tank is pyramidal in shape, with vertical walls rising to the surface in the form of a square. The sewage is made to enter the tank by a submerged pipe, the downward velocity being 1 to 2 ft. per second. As it emerges from the mouth of the pipe, it spreads out laterally and ascends to the square portion of the tank at a gradually decreasing velocity, the average velocity throughout being 7 ft. per hour. As this velocity approximates to the falling velocity of the particles in suspension, the tendency is for the latter to separate out and collect in that region of the tank between the mouth of the inflow pipe and the apex or bottom of the pyramid. The sludge-pipe terminates in a sump at the bottom, and whenever the pipe is opened by operating the sluice-valve, the sewage affluent ceases to ascend, or it may even become a downward flow precipitating the suspended matter towards the mouth of the sludge-pipe. The sludge or irreducible residuum of the septic process in this tank amounts to 1.027 tons of dry solid matter per million (imperial) gallons treated, and may be removed and buried for 8*d*. per million gallons, a figure that includes sludge main and labor, but excludes rent of land. The cost of an installation of the tanks of a sufficient capacity to effect the necessary reduction of suspended matter amounts to £520 per acre of bed supplied.

BIRMINGHAM, TAME AND REA DISTRICT DRAINAGE BOARD'S SEWAGE WORKS.

				Proportion of Time Bed Was Working, Resting and Idle, Due to General Causes. (Unity taken as 8,736 Hours.)						Cost of Treatment per 1,000,000 Imp. Gal., Including Cost of Silt and Separating Tanks and all Appurtenances.		
					Idle.							
Bed.	Date when Bed Brought into Use.	Volume Treated During 1906.	Rate per Square Yd. per Day Whilst Working.	Working.	Resting and Aerating.	Distributor out of Order.	General Causes. Causes.	Mech. Effi'y of Bed Without Regard to Deg. of Purification Calculated on 170 Imp. Gal. per Sq. Yd. per Day for 364 Days per Year. Per Cent.	Capital Cost of Beds.	Capital Cost.	Working Cost.	Total Cost..
		Gallons.	Gallons.						£	£ s. d.	s. d.	£ s. d.
A	Aug., 1903	34,419,215	109.9	0.693	0.062	0.176	0.069	43	2,149	3 2 4	18 1	4 0 5
B	May, 1904	41,907,212	112.7	0.876	.....	0.081	0.043	57	1,730	2 1 2	15 0	2 16 2
C	Feb., 1904	41,909,171	154.6	0.621	0.021	0.287	0.071	56	2,764	3 5 7	12 2	3 17 9
D	Oct., 1904	59,982,617	167.4	0.840	.....	0.121	0.039	83	2,481	2 1 4	11 6	2 12 10
E	April, 1904	137,389,645	169.3	0.935	0.025	.....	0.040	92	3,108	1 2 8	12 10	1 15 6
No. 4	Jan., 1906	236,940,249	144.0	0.956	.....	.....	0.044	79	6,216	1 6 3	7 3	1 13 6
No. 5 (Bays 1-6)	Sep., 1905.	216,216,247	160.4	0.944	0.017	.....	0.039	90	5,328	1 4 8	8 0	1 12 8
No. 5 (Bay 7)	May, 1906	11,012,306	139.1	0.526	0.422	.....	0.052	54	978	2 19 3		3 7 3
No. 6	June, 1905	259,218,438	160.6	0.932	0.029	.....	0.039	87	6,216	1 4 0	8 4	1 12 4
No. 7	May, 1905	265,987,358	163.8	0.929	0.031	.....	0.040	89	6,216	1 3 4	8 0	1 11 4
No. 8	Oct., 1904	261,979,793	166.3	0.894	0.068	.....	0.038	88	6,216	1 3 7	8 4	1 11 11

A biological filter should be constructed, whenever possible, on the percolation principle; it should rest on a concrete floor laid with an inclination towards an effluent-channel. Before the surface hardens it is advisable to lay thereon an aerating tile or false floor capable of sustaining the medium. The chief purpose of the aerating tile is to allow the free exit from the bed of all matter in suspension, whether due to disintegration or imperfect washing of medium, and to admit of the natural evacuations of the bed itself, such as colloidal matter, hydrated oxide of iron, sand, living and dead bodies of organisms, etc.; but the aerating floor also—as its name implies—provides for a free passage of air from end to end of the bed.

A percolation bed should be a permanent structure that requires no renewal, and little or no displacement of medium for cleansing purposes, and this can be obtained only by the employment of good rock or other equally durable material. The qualities next in desirability are roughness of surface, and pieces that approximate to cubes, so to prevent the particles from uniting too closely. Observe those conditions, and almost any medium will answer the purpose of providing a habitat for the bacteria. The accompanying table shows that no merit attaches to medium substance *per se*, and the beds which I am now constructing contain various kinds of stone (including gravel) and hard slag from different places, mixed together indiscriminately.

It must be admitted that the smaller the medium the more perfect the effluent depth for depth, but there are other and more important considerations than to obtain a perfect effluent. A perfect effluent is not an ideal one; the ideal is to obtain by natural means an effluent which will not putrefy, and which will continue to improve when it is discharged into a stream: this, when a strong sewage has to be purified, can be done for little more than half the cost by adopting large instead of small medium. Compare bay 7 with bay 6 of bed No. 5 on the table accompanying this note, and it will be seen that bay 7 (small) was at work for only one-half of its time, whereas bay 6 was at work 94 per cent. of the full time. The cost of purifying one million (imperial) gallons was £3 7*s*. 3*d*. against £1 12*s*. 8*d*. in favor of bay No. 6.

No doubt the purification obtained was greater in the case of bay No. 7, but what of that when both effluents were non-putrescent?

It cannot be too often reiterated that what may be a suitable medium for one sewage may be quite unsuitable for another. The character of the effluent desired, the depth of the percolation bed, the quantity of sewage to be dealt with, the periods of rest necessary, and the facilities for removing suspended solids, all have a direct and reciprocal bearing on the selection of the most suitable size for media.

One of the most important questions to consider is the best way to distribute sewage over the surface of a bed, and it will probably be admitted that the ideal to be aimed at is an imitation of rainfall. The fixed spray jet breaks up the liquid into fine particles better than any other method hitherto adopted, but it fails to distribute an equal quantity over the surface. In this respect it is inferior to a power-driven distributor, whether it rotates round a circular bed or travels up and down a rectangular one; on the other hand, it is much cheaper, *e.g.*, spray jets cost (initial outlay) £500 per acre against anything between £1,000 and £4,000 required to install moving distributors, and reference to column 4 will show how much time may be wasted owing to the repairs required by a mechanical apparatus. Now if it could be shown that the moving distributors were instrumental in producing better results, I should be the last to disparage the use of the traveling distributor on large works; but it cannot. Compare the results from bed D, which is served by a Candy distributor, with fixed spray jets on bed No. 6. In both cases the medium is nearly similar in size, the only difference being that bed D is 7 ft. deep, and bed No. 6, 6 ft. deep. The results show a purification of 83.6 in the case of bed D, against 80.4 in the case of bed No. 6, both non-putrescent effluents.

For a considerable time I have been suspicious of crystalline effluents, fearing that they would some day result in serious chokage in the bed itself. I have, therefore, encouraged effluents that contained as much or more suspended matter than was present in the sewage when applied to the surface, and as this represented from 7 to 8 parts per 100,000 of dry solid matter, it became necessary to arrest the solids before discharging them into the river. This was done by the Birmingham separator, constructed as already described. The cost is 1*s.* 4½*d.* per million (imperial) gallons treated; pumping silt and digging it into land, costs 6*d.* per million gallons more.

The accompanying table contains facts culled from weekly reports prepared for my own information and guidance; in it and others of like nature ample justification will be found for inculcating caution in estimating the amount of strong sewage which an acre-bed 6 ft. in depth is capable of purifying. On an installation of 20 acres of such beds at Birmingham, not more than 15,000,000 (imperial) gallons of dry-weather flow can be efficiently purified; with an occasional augmentation of a like quantity for a very short period. Again, the table shows that the adoption of fine medium, although capable of producing a slightly better effluent than large medium, is too costly to become popular; and lastly, the fixed spray jet for large works has not, so far, been seriously rivalled by the traveling distributor either for circular or rectangular beds.

A Large Gas Engine rated at 1,650 h.-p. at 107 r. p. m. when using furnace gas of 80 B. t. u. has recently been completed by the Wm. Tod Co., for the Ohio works of the Carnegie Steel Co. The unit consists of a pair of two-cylinder tandem four-cycle engines connected by an operating platform at the level of the axes of the cylinders. The latter are 30 in. in diameter and have a stroke of 42 in. They are held together by tie rods and are so mounted that they are remarkably free to expand and contract. The valve gear is driven by eccentrics, one for the inlet and exhaust valves of each end of each cylinder. Mushroom inlet valves are used, mounted on top of the cylinders, and the exhaust valves are at the bottom and readily accessible from the space below the operating platform. The main valve is opened by a rolling lever and seated by a spring. The mixing and governor valves are in the upper part of the valve bonnet and the former may be controlled individually or together by hand. A fly-ball governor is provided for each pair of tandem cylinders and the two governors are connected for ordinary operation although they may be disconnected if either half of the engine is to be used independently. Make and break ignition with 90-volt direct current is employed. The engine weighs 900,000 lb., and occupies a space of 27 x 60 ft.

The Municipal Ownership Investigation for the National Civic Federation.

The Commission on Public Ownership and Operation of the National Civic Federation has completed its work, and abstracts of its special reports are now being given out from time to time. Labor conditions and the character of the gas, water and electric service rendered by public and private plants are covered by the official reviews that have been made public up to the present. The Commission appointed a committee of investigation of 21 members, which engaged in turn a staff of engineers, accountants and statisticians to examine thoroughly every undertaking in this country and Great Britain which was visited by the committee. These experts were so chosen that, in each examination made, both sides of the municipal ownership question were represented. Thus, one engineer, accountant or statistician approached the subject under consideration favorably disposed toward municipalization, while his colleague began his task holding views in opposition to that principle.

Labor Conditions.—The labor conditions under private and public ownership are discussed by Prof. John R. Commons, of the University of Wisconsin, and Mr. J. W. Sullivan, editor of the "Clothing Trades Bulletin." Starting with the same information gathered by the experts as a basis for argument, the former reaches the conclusion that corruption under municipal control is no greater than under private ownership, while the latter makes caustic reference to political rottenness which he declares to be evident in Syracuse, Allegheny and Wheeling.

According to Prof. Commons, the investigations have shown that "the strongest safeguard for a manager against the pressure of outside recommendations is the recognition of organized labor within his department. Wherever we have found a class of employees organized and dealt with as such through their representatives we have found those positions exempt from politics. This follows from the nature of labor organization, which cannot survive if individuals are given preference on political, religious, personal or any other grounds than the character of the work they do. Even in the politically honeycombed municipal undertaking at Allegheny, the union of electrical workers stopped the practice of paying assessments by its members for political campaigns. The success of the civil system of Chicago is owing more than anything else to the fact that organized labor has one of the three members on each examining board. The manager of the Manchester tramways ascribes his freedom from interference by individual councillors to his recognition of the union that holds 90 per cent. of his motormen and conductors."

The minimum payment for common labor by the private companies in the United States, except in Atlanta, is lower than that of the cities investigated, and the hours of labor are langer. The laborers employed by the municipalities are in all cases citizens, but most private companies employ foreigners when colored labor is unavailable.

Mr. Sullivan sums up his observations with the conclusion that in all but the most poorly paid forms of labor, and for tramway employees, municipalization has not raised the wages or improved working conditions of the employees above conditions in the private undertakings. With respect to "common, unorganized labor," however, the investigators found a difference somewhat favorable to British municipal employees. The report cites two causes for this condition; first, that the municipal laborer is a picked man, and second, that this class of labor is capable of exerting on city councils a combined pressure which obtains for them better terms than the employing councillors accord to the men they hire in their private capacity for similar work. "No street car undertaking in Great Britain has ever been a 'private' enterprise in the sense in which the word is applied in this country," says Mr. Sullivan. "The twenty-one years' term of the franchise, the veto of company petitions by village authorities, the enormous cost of Parliamentary powers and local assents, and various other restrictions non-existent in the United States, shackle and impoverish British tramway company management and consequently forbid an intelligent investigator to employ British example to illustrate possibilities in America through change from private to municipal ownership. British tramways have always been semi-municipal. As by the terms of their franchises all English tramway undertakings may be taken over by the municipalities, directors manage their properties with that end in view. Compared with the remarkable changes for the better in wages and hours in the American street car industry under companies, the best of the British municipal labor improvements seem hardly more than trivial."

American Water and Lighting Plants.—The reports of the investigating staff for water and lighting plants have been reviewed by Vice-Pres. Walton Clark, of the United Gas Improvement Co.; Pres. Charles L. Edgar, of the Edison Electric & Illuminating Co., of Boston; Pres. Frank Parsons, of the National Public Ownership League, and Supt. Edward W. Bemis, of the Cleveland water-works. The experts examined the public gas works at Wheeling, W. Va., Richmond, Va., Holyoke and Westfield, Mass.; the private gas plants at Atlanta, Ga., Norfolk, Va., Philadelphia, Pa., and Fitchburg and Beverly, Mass.; the municipal water works at Cleveland, Ohio, Chicago, Ill., and Syracuse, N. Y.; the private water-works at New Haven, Conn., and Indianapolis, Ind.; the public electric light and power plants at Chicago, Ill., Allegheny, Pa., South Norwalk, Conn., Detroit, Mich., and Danvers, Holyoke, Westfield, Marblehead, Peabody, Taunton, Chicopee and North Attleboro, Mass.; and the private lighting plants at Northampton, Fitchburg, Salem, Beverly, Gardner, Abington and Attleboro, Mass.

The Wheeling gas plant is severely criticized by Messrs. Clark and Edgar, while the plants at Norfolk and Atlanta are considered satisfactory. They say: "If we consider together the price the Wheeling consumer pays for gas and the character of the service rendered, we may not doubt that he gets less of net result per dollar expended than does the gas consumer in Atlanta or Norfolk. Low and varying pressure, uncertain candle power, influenced at times by a dash of natural gas (at Wheeling), will bring troubles to studying children that, while not factors in financial calculations, has a proper place in this inquiry. Wheeling's gas plant is not an important factor in the well-being of Wheeling's citizens. What with fast meters, charges for service and meter setting, absence of any gratuitous work, the admixture of 15-cent, 8-candle power natural gas, insufficient and irregular pressure, and general inefficiency in the complaint department, Wheeling gas is a dear commodity at any price. Our experts found nothing to praise in Wheeling's service and little to criticise in the service of the companies at Norfolk and Atlanta."

Mr. Bemis, on the contrary, holds up the Wheeling plant as an example of what may be accomplished by a municipality, even under unfavorable political conditions. Despite its admitted defects, he says, the Wheeling experiment has been a financial success, and has been "the pioneer throughout the United States in low charges." He does not agree with Mr. Edgar and Mr. Clark as to the value of the free installation by the private companies at Atlanta and Norfolk, saying on this point: "The gas sold in Wheeling during the sixteen months ending with May 1, 1905, was 162,515,200 feet. The difference between the price charged at Wheeling, 75 cents, and at Norfolk and Atlanta, $1.00, or 25 cents multiplied by these sales, would be $40,628.80. In other words, the saving to the consumer in the price of gas in less than one year will cover all the difference between the free services and the meter setting from the curb to the house in Atlanta and Norfolk, and the cost of the same at Wheeling."

There is the same difference of opinion concerning the Philadelphia gas works. Messrs. Edgar and Clark quote Dr. L. S. Rowe as authority for the statement that the quality of the gas supplied has been improved by the company now operating the service, and that through the rental paid, the city has received for eight years an average profit of $491,674 annually, while for the last few years under city operation there was a loss of $245,398 per year. The private company, however, charges no more than did the city, but supplies better gas. "The Commission's records," say Messrs. Edgar and Clark, "indicate a high degree of efficiency in the company operation of the Philadelphia gas works, and kindly and liberal treatment of employees. On these latter points Dr. Rowe speaks as follows: 'As has been shown (under municipal management), there were abuses in almost every branch of the operation. The purchase of coal and the residual product were each under the control of favored individuals; the wages account was padded with incompetents, the friends of men prominent in city politics. It is unquestioned that there were leaks in the management of the gas works at other points than the distributing system; it is true that the labor account was debauched, and it is certain that in the purchase and sales departments there were influences at work which worked harm to the city's interests. But the loss through such sources was inconsiderable when compared with those inflicted by councils by the senseless blocking of the way to improvement in cutting off the appropriations for modernizing the plant. During the entire period of municipal operation the officers in charge were engaged in a losing fight to preserve the works from ruin. There never was a time during the entire period of responsible control when it could truly be said that the works were in an efficient condition.'"

Prof. Parsons claims that the experience at Philadelphia is of no value in settling the problem of municipal ownership. "It does not appear," he says, "that Philadelphia ever had real public ownership of the gas works. She had government ownership of gas works. But government ownership is not public ownership unless the people own the government. Philadelphia had the paper title to the gas works, but the people did not own or control them because they did not own the city government. The councils were full of the agents and allies of the private street railway, telephone, gas and electric light interests and they purposely mismanaged the gas works, allowed them to be filled with supernumeraries and let them get out of repair by refusing year after year to appropriate, even out of the receipts of the plant itself, the money necessary to keep it in order, so that they might have an apparently good excuse for executing a lease of the works to themselves. Philadelphia did not have real public ownership of gas, but one of the worst forms of private ownership—ownership by political grafters, in the pay of corporations, but masquerading as public servants."

With regard to water-works, Messrs. Edgar and Clark summarize the reports of the experts regarding the quality of the supplies in the cities previously mentioned as follows: "This phase of the question may be summarized with the statement that while the natural conditions in the different cities call for different methods of treatment, it is evident that the two companies examined were more solicitous regarding the purity of the water supply, and adopted more thorough means for insuring the same than did the three municipalities who ran their own water department. The conclusion drawn as a result of our investigation into the quality of the water is that the water supplied by the two companies is good, sanitary water; that its quality is much better than the water supplied in Chicago, somewhat better than the water supplied in Cleveland and quite as good as the water supplied at Syracuse. The latter place is blest with water from a source which, down to the date of this report, has remained pure without any special expense or effort on the part of the water department. It seems that the citizen obtains the cheapest water in Cleveland, while New Haven is the second cheapest. At Indianapolis the poor man gets water fairly cheap, but the cost increases rapidly as the class of dwelling improves. At both Chicago and Syracuse the poor man pays a high price for water.

Mr. Bemis, on the other hand, quotes the following typhoid fever death rates as proving municipalities are furnishing good water, as the lowest rates are in cities with public plants:

	New Haven.	Indianapolis.	Chicago.	Syracuse.	Cleveland.
1905	42.8	30.2	16.5	7.1	14.9
1906	52.0	34.2	18.1	9.2	20.2
Aver. ...	47.4	32.2	17.3	13.2	17.6

In reviewing the charges for water, he states that the rates are more favorable to the consumer with municipal plants, and particularly commends the low meter rates at Cleveland. He also declares that in spite of great reductions of rates in Syracuse on going from private to municipal ownership, and the phenomenally low charges for all residence consumers under the present meter system in Cleveland and the moderate charges also in Chicago, the financial results of municipal ownership, from the standpoint of the community and the taxpayer, are far better in the three municipal plants than in the case of the two private companies studied.

The municipal electric plants are criticized in various adverse ways by Messrs. Clark and Edgar. They state that the municipal lighting department of Chicago is run at an annual loss of $11.07 per lamp, although the city claims it makes a profit; that the character of the South Norwalk plant is such that the current costs 20 per cent. too much; that the Detroit plant is old and incapable of expansion, and the Allegheny plant is poorly designed, inefficient and expensive to operate. Mr. Bemis, on the other hand, states that the South Norwalk plant is one of the most successful in the world, and the Chicago plant is furnishing light at a lower cost than a private company would charge for similar service. Detroit, he considers the most successful plant after South Norwalk. Allegheny, he claims, has saved enough to pay for her plant out of the difference between her operating expenses and the $96 a year Pittsburg paid for similar arc lights prior to 1906.

Municipal Ownership in Great Britain.—The investigations made by the experts sent to study municipal ownership in Great Britain have been reviewed by Mr. Milo R. Maltbie, a member of the Public Utilities Commission, of New York City, and by Messrs. Clark and Edgar. Mr. Maltbie declares that, of the plants examined, those operated by municipalities gave in almost every instance a superior service at a lower cost than the private works. He does not consider actual ownership and operation to be necessary for the success of the municipal ownership idea; the power of a city to operate a public service undertaking has been as effective as actual operation in some cases. The same expert reports are held by Messrs. Clark and Edgar to prove that municipal ownership is productive of many and serious ills with little or no compensating good. They see various present difficulties which can only be met by electing municipal officers who will protect the people against injustice.

The gas plants examined by the Investigating Committee of the Commission were those conducted by the municipalities of Birmingham, Glasgow, Manchester and Leicester, and by private companies at Sheffield, the Newcastle and Gateshead Company, and the South Metropolitan Company of London. On the important subject of maintenance of plants, etc., Mr. Maltbie says that during last year every municipality set aside out of earnings a larger total to maintain or extend the plant or wipe out indebtedness than did any private company. As to the price of gas to the consumer, Mr. Maltbie points out that the private company at Sheffield is able to buy good gas and coke-making coal at a lower price than any other company or municipality and finds a market for its coke at its very door in which it receives more per ton than any other undertaking save one; and that it sold its by-products for more than the cost of its coal, oil and other supplies, making profit thereon of 2.13d. per thousand cubic feet of gas sold. No other undertaking was so fortunate, and a comparison as regards prices and costs between Sheffield and any other plant not so well situated would be misleading and unfair.

Mr. Edgar and Mr. Clark open their comments on the British gas situation by pointing out that the private companies supply gas at lower prices than do the municipalities. Thus, the relatively small cities of Newcastle and Sheffield get cheaper gas from private companies than do the larger cities of Manchester, Birmingham or Glasgow. The difference in cost per ton of coal does not explain this difference in the selling price of gas, according to the reviewers, who find that the greater efficiency in management and in energy in selling the by-products has much to do with the lower prices. The service given the consumer by the private companies is declared to be superior to that given by the cities, although it is pointed out that the investigation of the candle power of the light supplied was incomplete in the municipal plants because of the declination of the authorities to permit the experts to make full examination.

"The whole question of the quality of the product of the municipalities is in doubt," say the reviewers. "The members of the Commission and the experts who are familiar with gas and photometry see no escape from the conclusion that the above facts show that the service of the municipalities is not what it is claimed, that the municipalities are unwilling to have the actual quality of their service determined by independent and competent authorities, and that the gas supplied by private companies is much superior in candle power to that supplied by municipalities.

"In the year covered by this investigation, if, in the city of Birmingham, the Newcastle price of gas had prevailed, the consumers would have been £262,600 better off; if the Sheffield price had prevailed, the Birmingham gas consumers would have saved £350,900. The amount paid by the Birmingham gas undertaking into the common good was £69,813. So it seems that this city is playing a losing game with its municipal plant; it is mulcting its gas consumers from £250,000 to £350,000 a year in order that it may help out the municipal treasury with a paltry £70,000.

"In the case of Manchester, if the Newcastle price had prevailed, the gas consumers would have saved £47,500; at Sheffield's price they would have saved £111,300. The amount contributed to the city treasury by the gas business was £60,000.

"In the case of Leicester, at Newcastle's price, the consumers would have saved £65,200, while if Sheffield's price had obtained they would have saved £90,500. The amount contributed by the gas business to the common good was £43,466."

A Problem in Underpinning.

The Mount Royal pumping station in Baltimore is one of the handsomest water-works stations in the country. It was designed for three 17,500,000-gal. Worthington horizontal triple-expansion engines and four batteries of two 200-h.-p. water-tube boilers, and has been a source of much pride to the city. It was recently asserted that the walls at a corner of the engine-room were insecure and underpinning operations have been commenced to strengthen their foundations. In an article in this journal on March 24, 1900, the following statement was made concerning the foundations: "After the site had been selected, test pits were driven at a number of points within the proposed limits of the station and bed-rock was found uniformly at a depth of 30 to 35 ft. To carry the walls, circular concrete piers from 4½ to 12 ft. in diameter were built up at intervals from the rock to about the height of the basement floor, and the spaces between the piers spanned with masonry arches springing from the piers as abutments. . . . As a large storm sewer runs through the site directly underneath the buildings, considerable trouble and ingenuity were required to locate the foundations so as not to strike this sewer, and at the same time properly distribute the weight of the superstructure and permit of the desired architectural effect."

The wall of the engine-room cracked somewhat in one corner and this was asserted to be due to failure to carry all the piers to bed-rock. The architect of the building, Mr. Henry Brauns, stated that the cracks need cause no apprehension, but the mayor determined to underpin the walls. Since the work was begun, Mr. Brauns made a strong protest against its character in a letter to the mayor, and submitted with it a report on the methods, written by Mr. Richard C. Sandlass, chief engineer and general manager of the Chesapeake Iron Works of Baltimore. This report discusses underpinning work from a point of view rarely mentioned in print, as will be seen from the following extracts from it. It was based on measurements made at a time when two of the needles, Marked 4 and 5 in the accompanying diagrams, were not in position, but openings cut in the wall showed their location.

The needle marked 1, consisting of three 18-in. 55-lb. I-beams 29 ft. long between centers of bearings has to support, Mr. Sandlass says, a concentrated load of 179,610 lb. arising out of one-half of the weight on pier 41 and one-half of the weight on pier 42, as shown in the diagrams. This load causes a stress of 56,400 lb. per square inch of section in these beams, and is very close to their ultimate strength. This is aggravated by the fact that the beams incline about 1 in. in 1 ft.

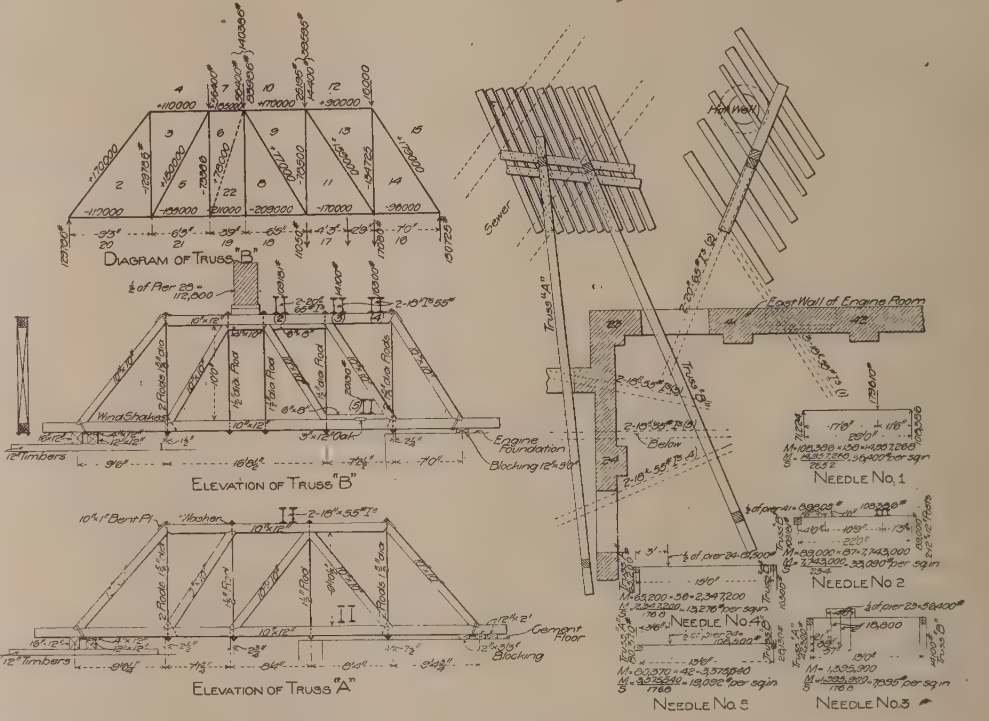
Needle 2, consisting of two 20-in. 65-lb. I-beams 22 ft. long between centers of bearings has to support two concentrated loads, one arising out of the reaction of needle 1, which is 108,386 lb., the other from one-half load on pier 41, which is 89,805 lb. This load produces a stress of 33,090 lb. per square inch of section in these beams, which is about the elastic limit of the material.

Needle 3, consisting of two 18-in. 55-lb. beams 13 ft. long between centers of bearings, receives a concentrated load arising out of one quarter of the weight on pier 23, equal to 56,400 lb., which causes a tensile stress of 7,895 lb. per square inch of section in both of the beams.

Needle 4, which was not in position at the time of the examination, consisting of two 18-in. 55-lb. I-beams 15 ft. long between centers of bearings receives a load of one-half of the weight on pier 24, equal to 81,500 lb., which causes a tensile stress of 13,276 lb. per square inch of section.

Needle 5, which was not in position at the time of the examination, receives a load of 10,500 lb., arising out of one-half of the load on pier 24, and two 18-in. 55-lb. beams would be sufficient in this case, as there is a stress of 19,092 lb. per square inch of section arising from this load.

Truss B receives a total load of 280,511 lb. distributed over four panel points in the top chord and two panel points in bottom chord, arising out of the reactions of needles 2, 3, 4 and 5 and from one-half of load on pier 23. The end post 14-15, of 10 x 10-in. Georgia yellow pine, 14 ft. 6 in. long between chords, with an area of 100 sq. in., receives a compressive strain of 179,000 lb., which is equal to 1,790 lb. per square inch. The ultimate strength of a post this length, about 5,757 lb. per square inch, divided by 1,790 lb., gives a safety factor of 3.2.



Underpinning Employed at Mount Royal Pumping Station.

Bottom chord number 8-18, consisting of 10 x 12-in. Georgia yellow pine, having a net area of 102 sq. in., receives a tensile strain of 209,000 lb., or 2,049 lb. per square inch. Bottom chord 11-77, being 10 x 12-in. Georgian yellow pine, having a net area of 105 sq. in., receives a tensile strain of 170,000 lb., and a moment of 563,640 in.-lb., arising out of the reaction of needle 5. This causes a tensile stress of 4,210 lb. per square inch. This gives a safety factor of three, assuming the ultimate resistance of the timber to tension as 12,600 lb. per square inch. While all these stresses in wood members of the truss referred to are in excess of those usually assumed in good engineering practice, Mr. Sandlass states, especially in view of the fact that the timber used is not of the very best, the wooden portion of the truss will probably carry the loads that come on it now with a small margin.

The unit stresses in the steel rods of the trusses, however, are considered by him to be so excessive as to endanger the construction, inasmuch as member 14-13 consisting of two rods 1⅝-in. in diameter not upset, each having a net area of 1½ sq. in., receive a total stress of 44,908 lb. per square inch. The net area of 1½ sq. in. of rod is assumed at the root of the thread.

Member 9-11 consisting of one rod 1½-in. in diameter, having a net area of 1.35 sq. in., receives a total tensile strain of 78,500 lb. This, however, divided by the net area gives a stress per sq. in. of 57,810 in. The reaction of 109,181 lb. of needle 2 causes a compression in the top chord, crosswise, of 873 lb. per square inch and is mostly on one edge of the top chord only, inasmuch as this needle has a slight incline. The ultimate resistance to compression crosswise of Georgia yellow pine is about 1,260 lb. per square inch, which would leave but little margin for safety.

The timber foundation under the east end of trusses B and A consists of one 12 x 16-in. timber, one 12 x 12-in. and one 4 x 12-in. laid flat, and distributes the reaction of both trusses over twelve timbers 6 x 8-in., 8 x 8-in., 8 x 12-in. about 16 ft. long aggregating about 205 sq. ft. The total reaction of truss A being about 87,000 lb. and truss A 130,000 lb. makes a total of 217,000 lb. and this divided by the area of the timber gives a total load of 1,058 lb. per square foot on the ground. While this is not considered by Mr. Sandlass to be excessive on firm or even bad ground, he does not regard this foundation as absolutely safe because it is immediately above a large sewer.

The foregoing calculations are based on loads figured from the architect's drawings, but Mr. Sandlass reduced all crane, roof and floor loads by half in order to eliminate live loads in the calculations. This, while not exactly conservative, would with proper safeguards be permissible in this case, he believes. All wall loads assumed in the calculations do not include the weight of the wall from the engine room floor to the concrete foundations, except in the case of needle 5. If the full wall loads are ultimately carried by the trusses the strain in the different members will be proportionately increased. Truss B is not considered by Mr. Sandlass as a perfect system inasmuch as it should have another brace 6-22, indicated in the diagram by a dotted line, in order to develop the full capacity of the truss.

Power Plant of the West Street Building, New York City.

The West St. Building is a 23-story, steel-cage structure recently completed on West St., on the Hudson River front, in New York City. It is intended solely for office purposes, to which all floors above the basement are devoted. It occupies an irregular plot about 120 x 160 ft. in extreme dimensions, with the West St. front parallel to and about 300 ft. distant from the Hudson River bulkhead line. Interesting structural features of the building and of the substructure, necessitated by the proximity to the water front, were described in an article in The Engineering Record for Dec. 29, 1906.

It is a large building, rising to a total height of about 300 ft. above the sidewalk level, and having about 1,200 sq. ft. on each of its 23 floors, or a total of nearly 275,000 sq. ft. of floor space in the entire building, exclusive of the basement. The upper office floors can be arranged for subdivision into a maximum of 20 offices, if required, there being about 300 office groups in the entire building as it is now sub-divided, an average of about 12 suites to every floor. Accordingly an extensive mechanical plant was necessitated for the operation of the building, which includes not only the elevator and heating service, but also electric current for both lighting and power purposes. Besides this the usual auxiliary services have been provided for, including a vacuum outfit for office cleaning purposes.

Owing to the sub-structure conditions encountered in the construction of the building, very limited basement space could be provided, the difficulties in excavation rendering a minimum of sub-surface space advisable. Accordingly there is only a single basement with its floor level 11½ ft. below the main floor of the building, with the exception of a section in the southerly central portion where the floor was depressed some 7 ft. further, to provide ample head-room for the boiler equipment. The greater part of the basement is below ground-water level, so that the cellar floor and all the walls were carefully waterproofed to prevent leakage. Provisions have, however, been made to provide for the removal of any leakage that might possibly occur, consisting of a series of sub-floor drains which discharge through a 6-in. vertical cast-iron pipe into a deep central sump pit which has been provided for the natural drainage within the basement due to the leakage from piping systems and other causes. This pipe connection will normally be closed, but in case of unexpected leakage through the foundations at any place, it may be connected to a pump and water thus pumped from beneath the foundation and floors to keep the basement dry. This was installed as an emergency provision, however, and it is not expected that it will be needed under ordinary conditions.

About two-thirds of the basement is devoted to the mechanical equipment, that under the front portion and under the West St. sidewalk being used as store rooms for the offices and salesrooms on the main floor front. The space is divided into a 40x60-ft. boiler room in the south central portion of the basement, with a coal bunker under the Albany St. sidewalk; at the rear of this, a 30x85-ft. engine and dynamo room; a 15x50-ft. space in the center for the elevator mechanism and operating valves, and the large irregularly-shaped space in the northeasterly corner, 80 x 90 ft. in extent, in which are located the elevator pumps and tanks, the miscellaneous pumping equipment and other auxiliary apparatus. The head-room in the basement is very limited, averaging but 9½ ft. in the greater part, except in the boiler room which is depressed 7 ft. lower, giving 16½ ft. clear head-room to accommodate the overhead flue and piping connections. All inside drainage in the basement is accordingly directed to the boiler room in which there is at one corner a sump pit containing a 3x4-ft. cylindrical steel tank from which drainage can be removed by the sump pump. The interior of the pump and machinery sections is attractively finished, the ceilings and walls being plastered with an asbestos finish and the floors laid with tile. Very little daylight lighting is available, however, except at the outer edges of the basement where lighting is had through sidewalk lights.

For the generation of steam, four 250-h.-p. Keeler water-tube boilers have been installed. They are set in two batteries of two each between building columns in the boiler room, giving a total boiler capacity of 1,000 h.-p., while there is also space available for the addition of two more units of equal size. A 7-ft. space was left at the rear of the settings for the breeching and blow-off connections, while at the front there is a 12-ft. firing floor, in which an industrial track of 24-in. gauge is laid for the handling of coal and ashes. The former is, as above noted, stored in the bunker space underneath the Albany St. sidewalk, which is 10 ft. in width and extends from the boiler room to the West St. front. The floor of the bunker is depressed to the level of the boiler room floor alongside of that room, but to the west of the latter it was, for foundation construction reasons, raised to the level of the basement. The bunker is filled by dumping through sidewalk coal holes on the Albany St. side, and has a total capacity of over 200 tons. The narrow-gauge track extends into and through the lower portion of the bunker on which the charging cars are filled by shoveling, while in the raised portion at the front, there is a short section of the narrow-gauge track on which runs a 500-lb. dumping car into which coal may be shoveled and wheeled to the front for dumping into the charging cars on the lower track. There are two steel charging cars of one-half ton capacity, and a branch of the narrow gauge track permits them to be run around to the ash lift at the rear of the bunker for handling ashes in cans up to the sidewalk for removal. The products of combustion are removed from the furnaces through a 4½x5½-ft. breeching on the ceiling at the rear of the settings, which connects in the pump room with an elliptical steel stack rising above the roof line, to a level about 350 ft. above the grates.

The boilers are of the horizontal inclined tube type built by E. Keeler Co., Williamsport, Pa. They each have 124 4-in. tubes 18 ft. in length, which are arranged in 14 rows, each 9 tubes high. The steam drums are 48 in. in diameter by 20½ ft. long, to which the forged steel tube headers are directly attached, the total heating surface presented by each unit being 2,500 sq. ft. The boiler units are hung in steel frames, enclosed in substantial brick settings with brickwork arched over the steam drums, and are fitted with Ajax shaking grates of 52 sq. ft. grate area for hand firing. Owing to the arrangement of settings necessitated by lack of space horizontal baffles were required between tubes instead of the usual vertical arrangement. The boilers deliver steam at 150 lb. pressure and recent calorimeter tests at the plant indicate less than 0.99 per cent. of moisture. Each boiler has a 2½-in. blow-off connection from the rear tube header to a 3-in. blow-off line at the rear of the boilers which discharges into a blow-off tank, with cooling coil at the rear of the boiler room. This tank, being below the sewer level, is emptied by a duplex steam pump of 40 gal. capacity, which is under the control of a float mechanism adjusted to maintain the tank always partly filled. The boilers are fed by both injectors and pumps, each boiler having an independent injector, which draws from the city water connection and may be used for feeding or boiler testing, as desired. There are three pumps used for boiler feeding, each of which is a brass-fitted, outside-packed Platt Iron Works duplex pump of the double plunger type, having a capacity of 40,000 lb. of water per hour at 50 strokes per minute. Two of them, having 6x4x6-in. cylinders, are located at the rear of the boilers and connected to return condensation from the heating system, while the third, an 8x5x10-in. pump, is on the side of the settings and draws from city water connections or from the feed water heater, all delivering through a 3-in. feed line to the boiler fronts. The principal source of feed will be condensation returned from the heating system which is delivered to a 3x6-ft. condensation surge tank at the rear of the boilers and pumped thence by the condensation pumps under control of a pump governor through the feed main to the boilers. The feed heater is an exhaust muffler and separator tank, which is connected in the exhaust steam main and serves both as an oil separator and feed water heater. It is located in the pump room near the corner of the boiler room, and is 5 ft. in diameter by 9½ ft. long, being connected directly into the exhaust steam main with by-pass.

The high pressure steam piping departs from usual practice in that the mains are not in duplicate, the system consisting of a 12-in. header in the engine room adjacent to the boiler room wall, which has 7-in. supply connections from each of the boiler units and 5-in. delivery connections to the generator engines, a 3-in. live steam make-up connection to the heating system and an 8-in. delivery line to the steam pumping units in the pump room. All of the high-pressure piping is of extra heavy wrought-iron pipe with long-radius bends, the boiler branches having gate valves at the header and stop and check valves at the boiler nozzles. All of the high-pressure piping is run on the ceiling and is covered with 2-in. of magnesia covering, canvas jacketed, while the low-pressure piping from the engines and steam pump exhaust connections is carried in trenches to the muffler tank. The trenches extend to all engine cylinders and to all of the pumps, and are for the greater part 18 in. in depth, ranging from 20 to 36 in. in width. The low-pressure system consists of two divisions, one of which is a 12-in. line to the engine room and the other a 12-in. line to the pump room, the two joining into a 16-in. connection to the muffler tank, in the boiler room. The engine room division has 8-in. valve connections to each of the generating units and a 6-in. branch extending into the boiler room to receive the exhaust of the condensation sump and boiler feed pumps. The pump room exhaust main has 3 and 6-in. branches to a number of small auxiliary pumps and a 10-in. extension which serves the large and small elevator pumping units and the jack pump. From the muffler tank outlet, a 16-in. low-pressure riser is carried up to the roof of the building to connect with the overhead distributing mains of the heating system and thence through a back-pressure valve to the roof exhaust head. Condensation is dripped from all of the high-pressure piping by the Holly gravity return system, while for the low-pressure piping connections, there are two drip systems, one for the clean drip and the other for the oily drip; the former consists of all bleeder and drip connections from low-pressure piping, engine exhaust valves and other points where clean condensation water will be obtained, while the unclean drip system consists of the cylinder cock connections, the oil drip chambers, and the like. The clean drips are returned to the feed water heater and the condensation surge tank in the boiler room to be delivered to the boilers, while the unclean drips are discharged into the boiler room sump for delivery to the sewer.

With the original considerations of design, the electrical generating plant was laid out for a total capacity of 800 kw. to provide for a very heavy lighting load occasioned by some special illumination which was planned for a large tower on the roof of the building. Subsequently the tower feature and its illumination were temporarily abandoned and a total generating capacity of but 550 kw. provided, although space has been arranged for an additional 200-kw. unit to be installed at any later period desired. The present capacity is divided into two 200 and one 150-kw. units, so that with the addition of the possible future 200 kw. unit, the total generating capacity would be increased to 750 kw. The generating units consist of Western Electric slow-speed, engine-type generators which are direct connected to Fitchburg four-valve compound engines, which operate non-condensing. The engines are of the heavy-duty, side-crank type with Tangye frames and have the usual Fitchburg valve gear with double eccentrics for independent operation of admission and exhaust valves and giving results approaching very closely to that of the Corliss valve gear. The governors are of the centrifugal shaft type providing for a long range of cut-off and regulate within 1½ per cent. The two larger units have 16 and 24x26-in. cylinders and when operating at 150 r.p.m. and 125-lb. steam pressure have a capacity of 320 h.-p. The small unit has 14 and 22x20-in. cylinders and operates at 200 r.p.m., at which it has a rating of 225 h.-p.

A feature of the engine installation is the use of particularly massive engine foundations with sand cushions to prevent possible communication of vibration from the generating units to the building. All three of the engines are carried on a single large block of monolithic concrete, 3¾ ft. in maximum depth, which, it is calculated, will absorb initially the motion of the reciprocating parts of the engine. Between the concrete block and the underlying earth and also the adjacent building column footings, a continuous sand cushion is provided, which effectually maintains the position of the block yet insulates it mechanically from any part of the building. The sand cushion is made 6 in. in thickness in all horizontal planes and 3 in. in thickness between the edges of the block and the adjoining building foundations. The block is continuous longitudinally under the engine cylinders, being cut into at the fly-wheel ends only, in order to straddle building columns which are encountered. The engine equipment was installed complete by E. H. Ludeman & Co., New York.

The generators are multipolar direct-current generators wound for 125 volts, and arranged to operate on the two-wire systems for which the building is wired. They are compound wound, the over-compounding amounting to 5 per cent., with a variable shunt so as to allow maintaining the voltage constant automatically from no load to full load. They are so rated as to permit of operation at 33⅓ per cent. overload for two hr. duration without excessive heating. The generator and electrical distribution circuits are controlled on a 9-panel marble switchboard at the northerly end of the engine room, which consists of four generator panels, one totalizing panel and three lighting and one power panels. The panels have the usual equipment of instruments and switches, the total panel having wattmeters for both power and lighting services, a tie switch and ground detector equipment. There are 20 circuits controlling the lighting of the building and 15 circuits controlling the power circuits to the various motors, every motor in the building service being operated on an independent circuit for direct control from the switchboard. The generators and switchboards were built and installed by the Western Electric Co., New York, general contractors for the electrical installation.

The heating system of the building involves direct radiation throughout, operated with low pressure exhaust steam from the power plant, there being no mechanical ventilation provided for, except in the heated machinery sections of the basement. The radiation is proportioned in the usual manner to maintain the temperature of the interior to 70° Fahr. in all conditions of weather, the radiators being located under window-sills for direct counteraction of the glass exposure. Owing to the large amount of exterior exposure of the building and the open unsheltered position of the building itself, a large amount of radiation was necessary. Over 52,260 sq. ft. of radiation are installed on the main and upper floors of the building, which is an average of 2,270 sq. ft. on each of the 23 floors. Cast-iron Peerless radiators have been installed throughout, which are of the 4-column type, 23 in. high, on the main floor; in all corridors and elevator halls of the 2-column type, 39 in. high, while in all of the offices from the second to the twenty-third floors inclusive, they are of the 2-column type, 26 in. high, for location under window sills. A feature of the distribution of radiation is the location of individual radiator units under each of the outside windows, no matter how the office spaces are at present sub-divided; with this method the radiation is evenly and thoroughly distributed throughout all parts of the building and thus no future re-arrangements of office partitions will necessitate the changing or addition of radiators in any part of the building, as is usually the case in office building alterations.

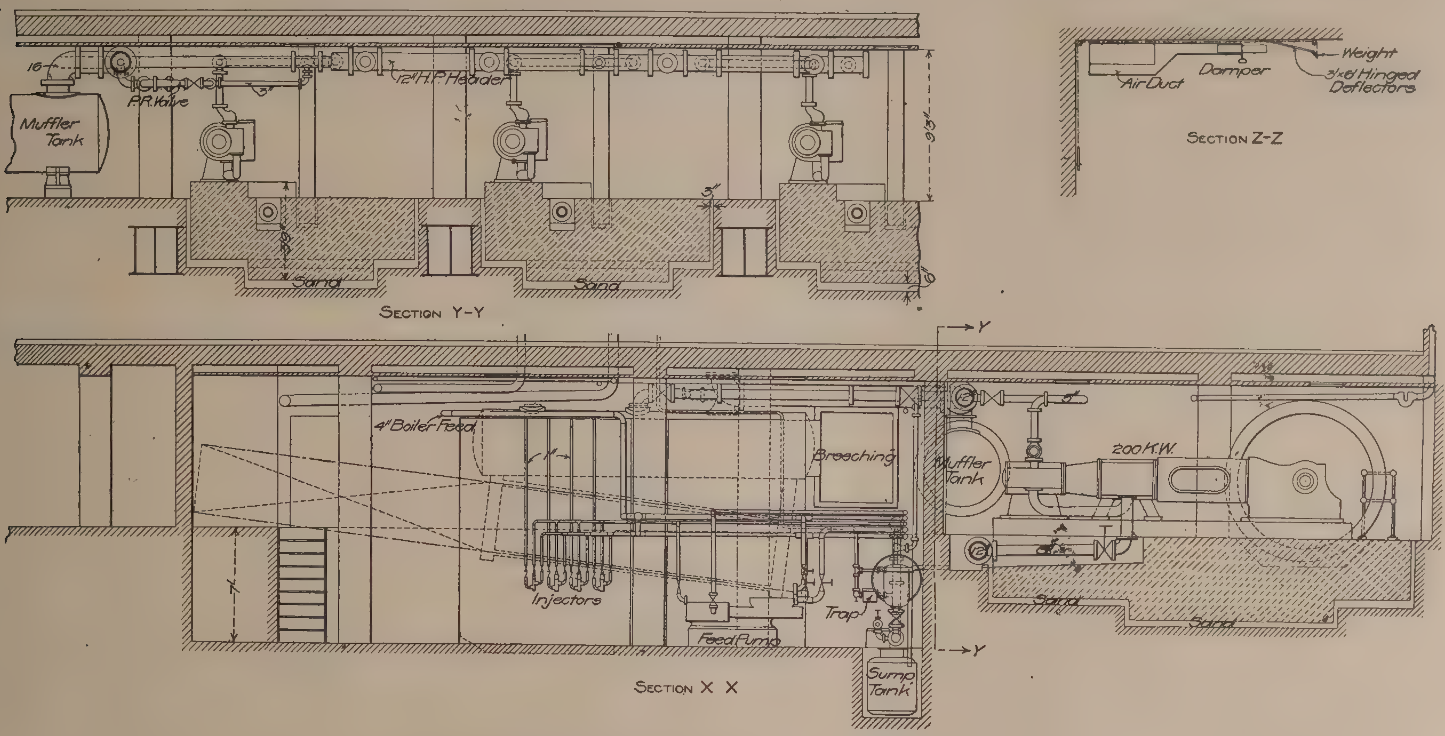
The radiation is supplied with steam on the one-pipe system with the Paul system of air-piping for positive circulation. The heating supply mains embrace an overhead distribution system to which down-feed risers are connected, the latter being connected at their lower ends in the basement to return gathering mains which deliver the condensation to the surge tank in the boiler room for return to the boilers. The heating supply system originates in the 16-in. exhaust steam riser which leads from the muffler tank in the pump room up to the roof of the building through the elevator shaft, and ends in a back-pressure valve and exhaust head at the roof line. At the 21st story level, a 16-in. branch connection is made from this riser to a series of distribution mains under the floor, which connect with and deliver steam to each of the entire group of 32 down-feed risers. This distribution system consists of a 12-in. line extending longitudinally through the building in either direction from the 16-in. connection, and supplying branches along the outer walls which taper in size as connections to the risers are taken off. These risers drop down from the supply connections as 3½ and 4-in. lines, tapering as connections are made to radiators, at the fifteenth floor to 3 and 3½ in., at the eleventh floor to 2½ and 3 in., and at the fourth to sixth floors down to 2-in. lines, which are carried through at that size to the basement return gathering mains. Twenty-two of the risers are carried above the twenty-first floor for the supply of radiation in certain portions of the twenty-second and twenty-third floors as 2-in. lines. Owing to the height of the building the expansion of these risers introduced a troublesome factor. It is provided for by the anchorage of all of the risers to the building construction at six points, namely, the fourth, seventh, tenth, fourteenth, seventeenth and twentieth floors, between which points slip expansion joints are inserted; the latter occur at five points, namely, above the fifth, eighth, twelfth, fifteenth and eighteenth floors, and consist of Crane iron-body expansion joints with brass sleeves.

The riser lines are, of course, all dripped directly into the condensation gathering mains in the basement with which the risers connect at the base. The return gathering system consists of a series of 3-in. lines which connect with the various branches from the risers and pitch sharply toward the condensation surge tank for proper drainage. Owing to the extreme distance of supply from the muffler tank in the basement to the lower floor radiators, by way of the twenty-first story distributing main, a dry equalizer system has been installed in the basement connecting the muffler tank and the lower end of practically all of the riser lines. This system consists of a 6-in. main extending from the muffler tank and parallel to the return gathering mains, which has 2-in. connections into the majority of the risers at points above the first floor level. These connections are so made as not to drain condensation from the risers, but to supply only such a limited amount of steam to them as may be necessary to equalize their lower ends against drop in pressure which might occur in case of heavy consumption of the low pressure steam.

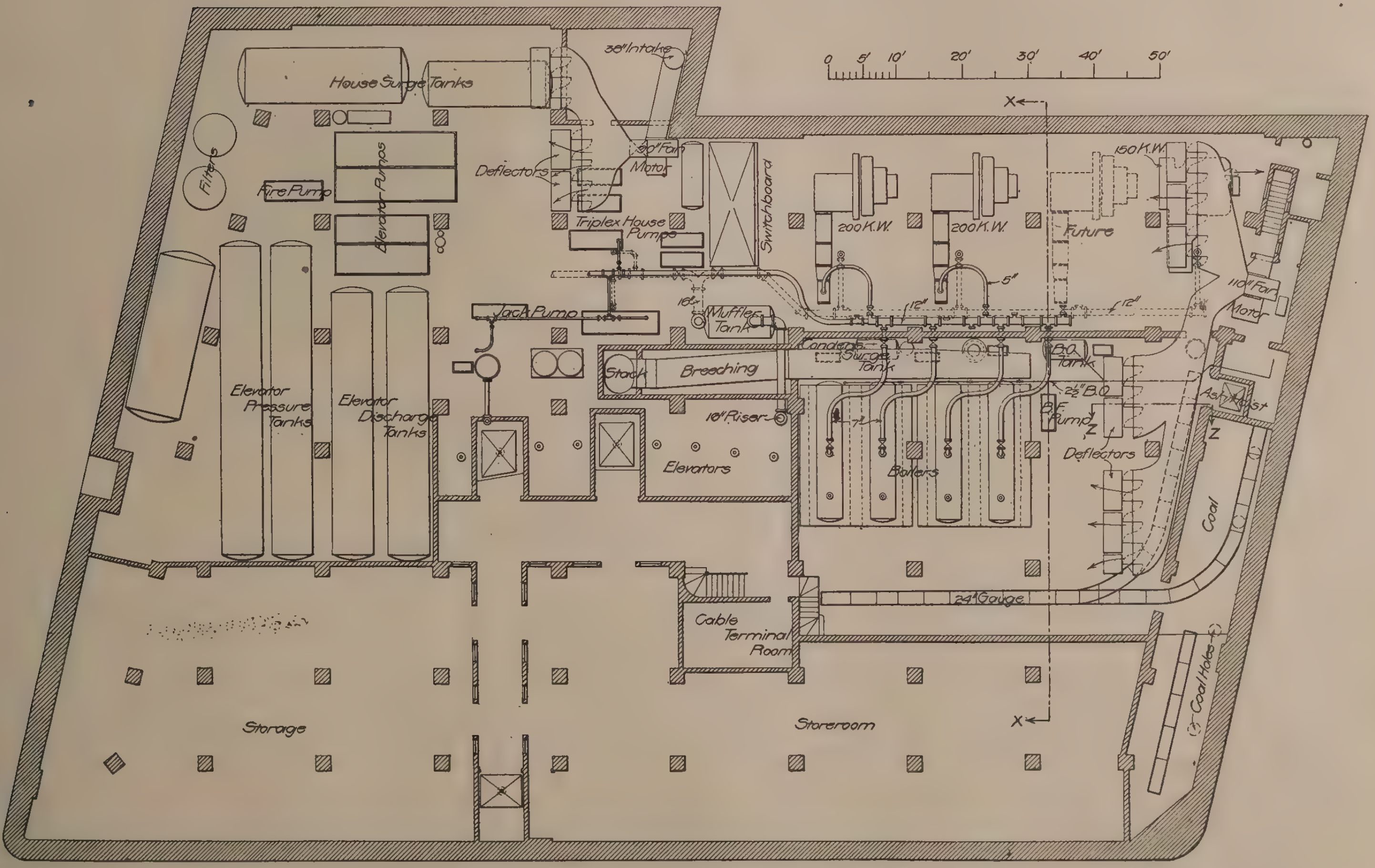
Ventilation is, as above stated, provided only in the heated machinery sections of the basement, where it is desired to moderate the temperature for comfort of the workmen. Communication of heat to the main floor is prevented by an asbestos ceiling finish in all machinery sections of the basement consisting of 1½ in. of asbestos plaster on wire lath, over a 1½-in. air space. The basement ventilation is accomplished by separate ventilating equipments installed for both the boiler and engine rooms, and the pump room, which are arranged to deliver untempered fresh air in either case. They are installed of sufficient capacity to change the air in the rooms served approximately twenty-five to thirty times per hour. The blowers are conveniently located, as shown in the basement plan, near outer walls, for in-take connections, that for the pump and machinery room under the lighting and ventilation court at the rear of the building, to which a 38-in. intake duct is carried up from the fan intake. The engine and boiler room system is conveniently located adjoining a stairway entrance from the Albany St. sidewalk into the engine room, so that the fan has a short direct connection from its intake to the open stair-well. The fans are 90 and 110-in. steel plate centrifugal fans of the full-housed peripheral-discharge type, built by the American Blower Co., and are driven by Western Electric motors of 12 and 25 h.-p. respectively, which operate on the power and lighting circuits of the building. The systems are each fitted with a novel arrangement of deflectors for directing the blast from the outlet registers in any direction desired for the comfort of the workmen. These consist of both horizontal and vertical vanes, the vertical vanes being butterfly dampers located directly in the duct outlet openings and may thus serve as dampers for adjusting the volume of flow, or to control the direction of the flow, in a horizontal plane; the horizontal deflectors are 36-in by 6-ft. galvanized iron sheets mounted on steel frames which are hinged to the ceiling in front of the register outlets and arranged for adjustment of position by cords passing over pulleys to the outer edge and controlled from the adjoining side-wall. The latter permit the blast to be diffused generally into the room or directed toward the floor close to the register outlets, while the butterfly dampers allow the air to be blown forward directly into the room, spread to the sides or partially closed off.

The elevator equipment of this building consists of nine passenger elevators and two sidewalk lifts, which are all of the plunger type installed by the Standard Plunger Elevator Co., New York. Five of the passenger elevators have travels from the first to the twentieth floors, a rise of 245 ft., two from the first to the twenty-third stories, a rise of 285 ft., one from the basement to the twentieth story, a rise of 256 ft., and the other from the basement to the twenty-third story, a rise of 296 ft. These are all operated by a 6⅞-in. plungers, working in 10-in. cylinders and with a hydraulic operating pressure of 180 lbs. per square inch, have a maximum capacity of 2,500 lb. each, or 1,500 lb. each at the maximum speed of travel of 600 ft. per min. A sidewalk lift on the West St. side of the building and the passenger elevator rising from the basement to the twenty-third story are fitted for operation with extra pressure for lifting safes and extra heavy weights; when operated by the jack pump for this purpose, they have a maximum lifting capacity of 8,000 lb. at a speed of travel of 50 ft. per minute. The other sidewalk elevator is an ash lift which rises from the boiler room floor to the Albany St. sidewalk for the purpose of communication with the boiler room and the removal of ashes.

The elevator plant is operated by a novel equipment of compound and triple expansion duplex pumps which provide in an interesting manner for emergency operation and reserve. There are two pumps, the larger unit a triple-expansion pumping engine with 15 and 24 and 36 steam cylinders, and a 14½-in. water cylinder, all with 24-in. stroke, while the other unit is a compound pump, having 16 and 26 in. steam cylinders, and 14½-in. water cylinder with 24-in. stroke. The pumps, although of duplex construction, are built with separable valve gear in both the compound



Sections through Boiler and Engine Rooms, West St. Building.



Plan of the Mechanical Plant of the West St. Building, New York City.

and triple expansion units, and have independent steam and water connections throughout, so that in case it is desired to operate at reduced capacity, either unit may be sub-divided into one-half of its total capacity and either side operated while the other is shut down. It is estimated that this arrangement has saved the installation of an extra pump, as there are thus provided four independent units, although under normal operating conditions they will be operated as two. For regular service the large triple expansion unit will be used, although while either side of this unit is under repairs, the other side and the smaller unit may be utilized as necessary. The pumping plant as thus installed is figured to be capable of operating the passenger elevators and sidewalk lifts when running on a schedule of a round trip every two minutes, for the passenger elevators, allowing five of them to go up at the same time, and a round trip of the sidewalk elevators every three minutes. The elevator tank equipment consists of two pressure tanks and two tanks for discharge, all of which are cylindrical steel tanks horiontally arranged in the front portion of the pump room, the two pressure tanks having each a capacity of 12,000 gal. and the discharge tanks a capacity of 10,000 gal. Air pressure for maintaining the necessary air space in the pressure tanks is furnished by two Westinghouse locomotive-type steam air pumps. The Jack pump is a 9x4½x10-in. duplex pressure pump which has independent piping connections to the sidewalk lift and the passenger elevator rising from the basement to the twenty-third floor. The entire pumping equipment was supplied by the Platt Iron Works Co.

For cleaning and renovating purposes a vacuum sweeping system was installed as a permanent part of mechanical equipment, embracing steam ejectors and dust separators in the basement with suction lines extending to all upper floors, the equipment having been installed by the American Air Cleaning Co., New York. This apparatus is located in the central portion of the pump room, and from the separators, a 3-in. vacuum line extends to either side of the building to connect with the two 3-in. vacuum risers in the corridors. These risers are conveniently placed for reaching any of the offices and at each floor there is a 1¼-in. branch connection ending in a 1-in. air cock attachment for the sweeper hose.

The architect of the building was Mr. Cass Gilbert, New York City, and it was built by the John Pierce Co., general contractors. The power plant, heating and ventilating and entire mechanical equipment was designed by Mr. Burt S. Harrison, consulting engineer, New York.

A DRY-DOCK, 1,050 ft. long and 114 ft. wide at the coping will be built at San Francisco by the San Francisco Dry Dock Co., from the plans of Mr. Howard C. Holmes.

Notes on Water Purification at St. Louis.

Abstract of a paper read before the American Water Works Association by Mr. W. F. Monfort, Chemist of the St. Louis Water Department.

The necessity of coagulation in purification of turbid waters of high color, such as occurs in many of our Western rivers, is generally recognized. It has been thought that the interest in the matter of coagulation and sedimentation as an essential part of any method of purifying such waters, whether in connection with, or apart from filtration by slow-sand or mechanical filters, will justify the presentation before this association of a brief statement of chemical and bacterial results for the past year at one of the larger plants, treating daily an average of 70,000,000 gal. of a water whose average turbidity is above 1,200, whose color is above 40, and of an alkalinity equivalent to 135 parts per million of calcium carbonate, using lime and iron sulphate as coagulants, without the use of filters.

The low-service pumping station and coagulating plant of the St. Louis water works system are located in the extreme northern part of the city at a point on the Mississippi River, about five miles below the mouth of Missouri. From this intake tower in the stream some 1,500 ft. from shore, the supply flows through a tunnel to a well or uptake shaft beneath the coagulant house, where it receives its charge of iron sulphate, thence through the inshore tunnel to the wet well. At this point it is freed from ice, when necessary, by bucket conveyors. From the wet well, the water with its charge of iron sulphate is lifted by the low-service pumps to the distributing well, where the charge of milk of lime from the coagulant house is delivered by centrifugal pumps. It then flows by gravity to a series of six uncovered sedimentation basins, 670 x 400 x 14 ft. (average depth), having a working capacity of about 24,000,000 gal. The weirs between the successive basins are 610 ft. long. A conduit runs on either side of the system of basins, allowing filling and drawing from any basin at will; in practice the end basins alone are used for filling. From the drawing conduit, the treated and settled water passes by a conduit 7 miles long to the most southerly high-service pumping station at Bissell's Point, where there are four smaller storage basins, and the clear well. From the latter as also from a basin connected with the conduit at an intermediate point three miles above, the high-service pumps deliver the water to storage reservoirs and to the mains.

TABLE 1. VARIATIONS IN RAW WATER. PARTS PER MILLION.

	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Turbidity.												
Maximum	2100	1200	3600	3600	1800	2400	1500	900	500	2400	1500	1500
Minimum	180	180	1050	1350	1200	900	500	400	275	400	120	700
Average	1358	975	2856	2261	1456	1398	866	702	375	1019	481	1183
Suspended Solids.												
Maximum	1645	1078	5301	4577	1769	1633	1191	944	496	3678	2537	2380
Minimum	394	122	842	1032	692	568	412	362	139	249	146	733
Average	1096	691	3417	2182	1164	947	691	592	264	1110	661	1444
Color.												
Maximum	51	51	41	41	45	41	41	71	70	65	70	70
Minimum	35	31	31	31	31	25	31	35	35	30	35	30
Average	52	38	33	36	35	34	35	52	57	49	49	45
Alkalinity.												
Maximum	127	148	146	129	139	143	176	175	172	167	176	152
Minimum	90	94	126	118	120	120	119	154	160	63	90	106
Average	110	134	134	123	129	136	147	163	167	107	145	133
Coefficient of Fineness.												
Maximum	0.914	1.41	1.606	1.272	0.983	0.907	1.007	1.203	1.102	2.415	2.024	1.602
Minimum	0.606	0.559	0.802	0.765	0.563	0.555	0.654	0.603	0.657	0.83	0.85	0.966
Average	0.827	0.708	1.17	0.963	0.80	0.677	0.798	0.844	0.836	1.33	1.37	1.22

TABLE 3. REDUCTIONS THROUGH THE BASINS.

	River.	Weir 1	Weir 2	Weir 3	Weir 4	Weir 5	Weir 6	Tap.
Suspended solids..............................	1444	14.2	12.1	8.35	7.1	5.8	5.46	2.56
Color	45.3	13.6	13.	13.	12.	11.6	10.8	10.8
Alkalinity	133.	51.1	48.6	47.	46.	45.	44.5	41.
Bacteria per ccm..............................	57029	933	....	501	....	106	......	42

The raw water partakes very largely of the character of the Missouri River water, being ordinarily so much higher in turbidity than the Mississippi above the confluence of the rivers that the line of demarcation between the two waters is plainly noticeable. As showing the variable character of the water, Diagrams Nos. 1, 2 and 3 are introduced, giving in graphic form the maxima and average for each month of the past year of a few prominent characteristics.

Fluctuations in turbidity of 2,000 or more parts per million occur in April, June, July, September and January; the difference between maxima and minima is less than 1,000 in May, November, December and March. The maximum turbidities for June and July were 3,600, for September and January 2,400, with a minimum of 120 for February. The year's average was 1,248 parts per million.

Fluctuations in suspended solids as determined by weighing are even greater than those of turbidity, being above 3,000 for June, July and January, about 2,000 for February and March and less than 1,000 for four months, May, October, November and December. The maximum of the year falls in June 5,300 parts per million or almost 31 grains per gallon, while for January it was 3,678 or 21 grains per gallon. The year's minimum was 122 parts per million or 7 grains per gallon. The monthly average follows generally the curves of maxima and minima. The year's average was 1,205 parts per million or about 70 grains per gallon.

The wide variation in the character of the suspended matter is shown in Diagram No. 2. From a minimum fineness of 0.555 in September to a maximum of 2.415 in January, with the year's average at 0.953, slightly less than the standard fineness. The peaks of June (1.6) and January (2.4) mark flood stage, with consequently coarser material transported.

The minimum alkalinity of the year, 63 parts per million, occurs in January flood water, when the variation was more than 100 parts per million. Otherwise the monthly variations lie within smaller limits of 10 to 80 parts per million. The average for the other months runs from 107 to 167 parts per million. The color range is from 25 to 71 with a yearly average of 43.

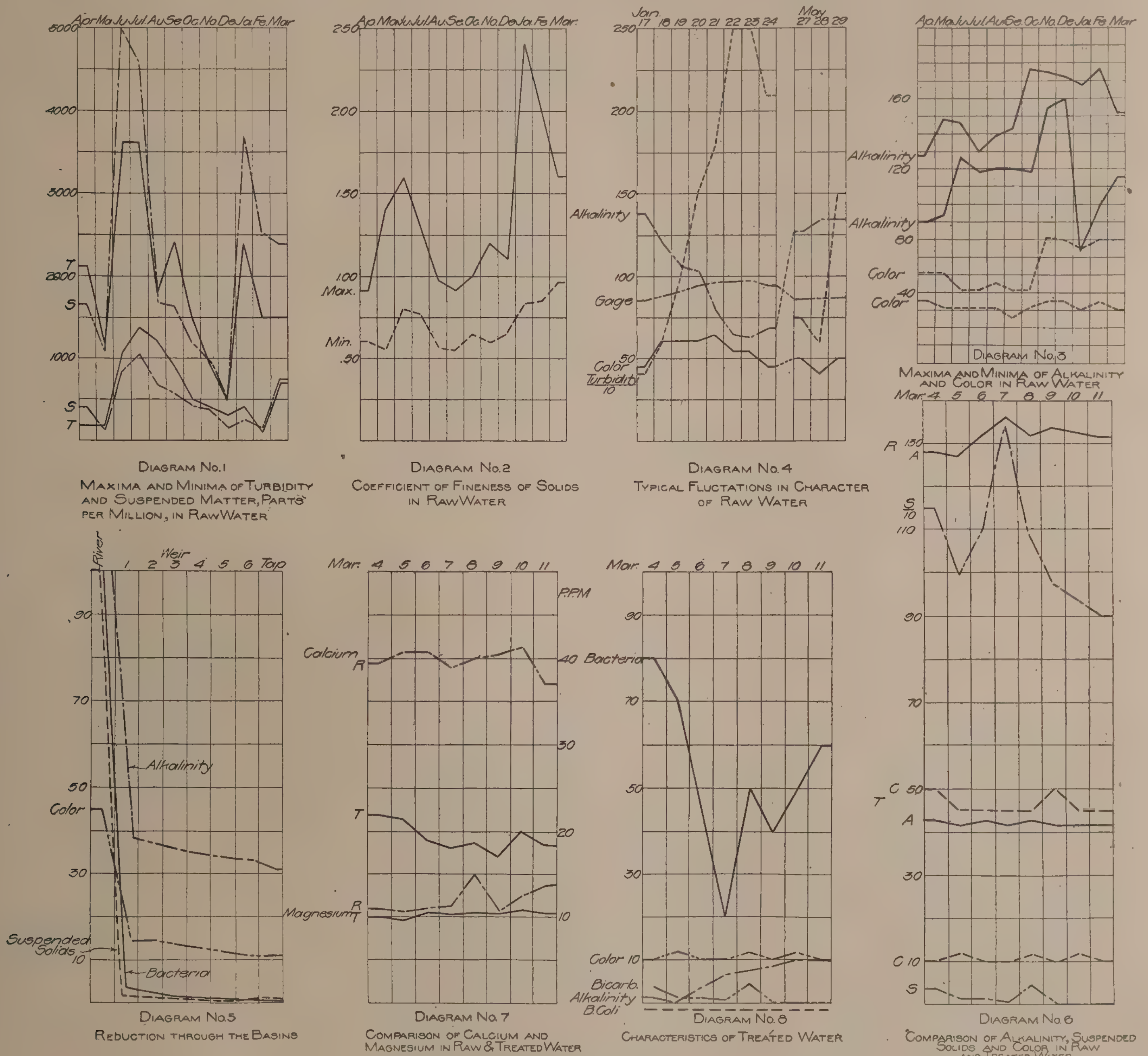
Diagram No. 4 shows two typical cases of fluctuation in character of the river water, the curves of this diagram having been plotted from the data in Table 2. From January 17 to 24 the river rose 11.5 ft., with a corresponding rise in turbidity from 400 to 2,500 parts per million, and a decline in alkalinity from 137 to a minimum on the 23rd of 63 parts per million. The dissolved solids declined from 255 to 138, color fluctuated irregularly, but remained high throughout. This is typical of a seasonable flood. It was on January 19 that the coefficient of fineness reached 2.4.

TABLE 2. TYPICAL FLUCTUATIONS IN CHARACTER OF RIVER WATER.

1907.	Gauge.	Turbidity.	Color.	Alkalinity.	Dissolved Solids.
Jan. 17	85.8	400	45	137	255
18	88.4	600	60	120	220
19	90.3	1000	60	107	192
20	94.0	1500	60	104	...
21	96.7	1800	65	80	138
22	97.1	2400	55	65	141
23	97.3	2400	55	63	142
24	96.9	2100	45	68	155
May 27	86.2	750	50	127	219
28	86.9	600	35	130	238
29	87.0	1500	50	130	221

The other case occurred in May, 1907, and is typical of the Missouri habit of cutting a new channel suddenly. Accompanying a rise of 0.1 ft. comes an increase of turbidity from 600 to 1,500 parts per million, while the dissolved solids, alkalinity and color waver slightly but independently of the turbidity. Cases less marked than this latter one have been of constant occurrence througout the year, wherein the shifting of the channel of the Missouri and of the Mississippi just below their confluence, has caused similar wide and sudden fluctuations.

It has been stated already that in the St. Louis plant the removal of suspended matter is accomplished without appeal to filters. On passing to the first or filling basin in the series of six previously mentioned, the coagulated



Diagrams Showing Characteristics of Raw and Treated Water at St. Louis.

water from the distributing wells carries its natural sediment and added coagulum. Sedimentation is so rapid that before the first basin is traversed the water is very largely clarified. The turbidity is reduced to about 15 parts per million on leaving the first basin; most of the suspended matter is fairly coarse at the first weir, and drops out in passing the succeeding basins, so that at the third weir the turbidity approximates 12, at the fifth 10 or less. It will be understood that the suspended matter in the earlier basins is too coarse for accurate determination by optical methods. Direct weighing of the suspended matter show results which are tabulated with other data in Table 3.

The figures given are monthly averages for March, 1907. The daily data for the same period vary but slightly from the averages. In the accompanying diagram, No. 5, these data have been reduced to a percentage basis, save the color, which is platted in parts per million.

Accompanying a reduction of suspended matter to less than 2 per cent., the bacterial reduction through the basins goes with almost even progress. When it is remembered that a portion of the suspended matter carried over the weirs is adventitious, produced by the softening reaction, and not bacteria laden, as is the original river sediment, it will not be surprising that the sudden decline in the solids has accomplished the removal of so large a percentage of bacteria. Most of the original sediment and the coagulum fall out in the first half of the first basin, leaving the deposit heaviest about the filling gates.

Basin No. 1 was put into commission January 8 and the March data plotted show results in the third month of use. It must be stated, however, that the sewer of the filling basin is opened daily without interrupting its use, to allow the lighter accumulated flock and sediment to flow out.

The March averages plotted in Diagram No. 5 are representative of the best working of the system and of the best results attained. During the period January 8 to March 30 the average removals were almost as satisfactory, as shown in Table 4.

Table 4. Average Bacterial Removal—Per Cent.

	Basin 1.	3.	5.	Tap.
Jan., 1907	93.7	96.	97.4	98.87
Feb.	95.9	98.4	99.0	98.8
Mar.	96.1	99.1	99.8	99.88

As typical of results through the year a period in March, showing the character and extent of the changes in the raw water effected by the treatment, was selected for presentation here. The results obtained during this period are given in Tables 5 and 6, and are shown graphically in Diagrams Nos. 6, 7 and 8.

Consideration of the Diagram No. 8, makes it evident that there is no necessity for carrying caustic alkalinity through the basins to secure satisfactory bacterial removals. Not only was the tap water free from caustic during the period under consideration (March 4-11), but no caustic appeared in any samples on passing weirs 1, 3 and 5, save on the 9th and 11th of March. This conclusion finds further support by consideration of daily data for the entire month, as well as the longer period, January to March. It appears, further, that removal of colon bacillus is likewise not dependent upon the presence of free lime through the basins, since tests for coli were negative throughout the week represented by Diagram No. 8, and also throughout the month.

Table 6. Averages of Raw and Tteated Water—March 4-11, 1907.

	Raw.	Treated.
Alkalinity	132 p.p.m.	42 p.p.m.
Susp. solids..................	1079 "	1.7 "
Color	46 "	10.7 "
Calcium	40 "	19.4 "
Magnesium	12.1 "	10.5 "
Bacteria	94000 "	50 "

Table 5. Comparison of Raw and Treated Water.

1907.	Suspended Solids.		Color.		Alkalinity.		Calcium.		Magnesium.		Bicarb. Alka'ty.	Bacteria.			
Mar.	R	T	R	T	R	T	R	T	R	T	T	R	T	Per cent. Removal.	Coli.
4	1146	4.0	50	10	128	43	39.9	22.0	11.1	10.0	1	166,000	80	99.94	...
5	991	1.6	45	12	127	42	40.8	21.5	10.7	9.7	0	149,000	70	99.99	...
6	1103	1.6	45	10	132	43	40.9	19.3	11.1	10.7	3	95,500	40	99.9	...
7	1343	0.8	45	10	136	42	39.2	18.4	12.5	10.3	6	105,100	20	99.99	...
8	1087	4.8	45	12	132	43	40.0	18.8	15.	10.7	7	48,750	50	99.9	...
9	972	0.0	50	10	134	42	40.5	17.0	11.1	10.7	8	59,000	40	99.9	...
10	....	...	45	12	133	42	41.5	20.2	12.5	11.1	10	......	..	....	...
11	903	0.0	45	10	133	42	37.0	18.6	13.6	10.7	10	34,800	60	99.8	...

The averages given for this period differ but slightly from the averages for the year, save in the extent of the removal of the magnesium, and in the actual number of bacteria per cubic centimeter, which are unusually low.

The raw and treated water at Bissells' Point (the Southerly high-service station) for the year averaged as follows:

	River.	Treated Water.
Suspended solids...............	1,188	3.8
Color	43	10.7
Alkalinity	135	49.
Calcium	42.3	22.8
Magnesium	13.1	4.5

being a reduction of the calcium to 54 per cent. and of magnesium to 57 per cent. of the original content of the raw water. In the river water there is approximately 0.05 parts per million dissolved iron; in the treated water 0.02 parts per million dissolved iron, while the total iron content of the water from the clear well varies from 0.1 to 0.25 parts per million. Most of this is in the form of ferric hydroxide adherent to or absorbed by fine suspended siliceous matter and is in large part carried down with it in the after reactions, which are still incomplete in the clear well.

The color reduction has not been pushed below an average of ten because the popular appreciation of colorless water has not yet developed beyond this point in the scale.

With reference to the matter of cost, it may be said that on an average 2.13 grains of iron and 7.39 grains of lime have been used and the following is the detailed cost per million gallons of water treated:

Iron, $1.442; lime, $2.454; making a total chemical cost of $3.896; labor, $0.579; power, $0.064; improvements, $0.021; repair, $0.063; producing a total cost of treatment $4.623 per million gallons treated. The waste of water due to the daily flushing out of loose sediment from this filling basin, together with that used in flushing out the accumulated deposit when the basins are cleaned is approximately 2 per cent. of the amount pumped.

Some members of the association may be interested in a method for continuous slacking of lime for water treatment which has been introduced at St. Louis during the past year as a result of an investigation carried on by the writer—based upon the heat of hydration of lime, and the increase in efficiency of the milk of lime produced by hot slaking.

Prior to this year the method of slaking used at St. Louis since the installation of the plant was as follows: Cooling water from an auxiliary condenser was heated to 129° Fahr. by live steam, and the water thus used for slaking, giving a maximum temperature in the tanks of about 180°. During part of the past year a higher initial temperature (approximately 160° Fahr.) was maintained for the hot-water supply, and a temperature of 200° or more in the slaking tanks, since it appeared that using the same lime in like slaking tanks with only the difference in the initial temperature of the water, the efficiency of the effluent from a tank in which a temperature of 200° Fahr., or more, prevailed was 15 per cent. greater than when a temperature of 165 to 170° Fahr. prevailed. In other words, a serious loss in efficiency was caused by the low temperature of the water used. The accompanying Table 7 shows results of several series of comparative experiments, the same lot of lime being used throughout the experiments of each series.

Table 7. Results of Comparative Experiments to Determine Effect of Warm Slaking Water.

Series.	Tank.	Initial Temperature of Water. Deg. Fahr.	Maximum Temperature of Suspension. Deg. Fahr.	Efficiency. Per cent.
A	1	110	156	70.3
	1	120	171.3	78.13
	4	122	156	72.85
	3	172	202	83.65
B	4	127	165	66.04
	3	165	200	81.25
C	4	117	153.5	79.35
	3	172	208	94.6

For several months a device has been in use which heats the hydrant water supplied for slaking by utilizing the heat developed in the slaking process.

The effluent milk of lime from the slaking tank flows through a circular steel tank. A coil of 2-in. copper pipe is submerged in this latter tank, the contents of which are agitated by paddles on a vertical shaft. The hydrant water passes through this coil to a head tank, its temperature being raised during the passage from 60 to 70° Fahr. above the initial temperature of the cold water. From the head tank the hot water flows through adjustable orifices to the slaking tanks, where a temperature of 200° Fahr., or more, has been maintained by the heat of hydration. In a long series of observations these are representative temperatures:

Cold Water.	Head Tank.	Lime Tank No. 1	Lime Tank No. 2.	Heater Tank.
51	118	204	200	134
51	118	206	203	136
51	114	206	204	135

The apparatus has been successfully operated since February, and in a slightly modified form is incorporated in the plans of the new coagulating plant for which bids have been recently received. The suspension used is adapted to the individual tanks. Two of the slaking tanks now in use have short pipes carrying the effluent to the heater tank. These have their water supply adjusted so that the milk of lime has one pound of lime in 3½ lb. of water. In two others having longer effluent pipes of 6 and 8 ft., respectively, a suspension of 1 to 3¾ is maintained. Inasmuch as it is necessary to cool the milk of lime before it passes the centrifugal pumps, the amount of water needed for this purpose is actually reduced, making the process economical from every point of view. The estimated saving over heating the water by live steam is nearly $3,000 per year.

The residue left in the slaking tanks after sixteen hours continuous operation is reduced to less than 1 per cent., where formerly 3 per cent. was a minimum. There is thus a further economy of time and labor in its removal.

The Natal Government Railways in 1906 operated 880 miles of line, the earnings from which amounted to $10,443 per mile, and the return after paying for operation and maintenance, $3,412.80 per mile. The gross earnings per train mile were $1.905. The new lines constructed during the year brought the total mileage of the system to 1,024 miles, most of which is of the standard gauge of the colony, 3½ ft., the remaining mileage being 2 ft. gauge. Most of the rail is 61-lb., though 313 miles are laid with 78-lb. rail.

Reinforced Concrete Abutments on the Atlanta, Birmingham & Atlantic R. R.

The bridges of the Atlanta, Birmingham & Atlantic R. R., which has now over 300 miles of line under construction, are of two general types; semi-circular concrete arches up to 30 ft. in diameter, and for larger openings steel bridges on plain concrete piers and reinforced-concrete abutments. The resident engineer on each ten miles of line determines the waterway required for each bridge, either by making a survey of the run-off area and calculating the required waterway by Talbot's formula, or by measuring at the site the stream section below the high-water line.

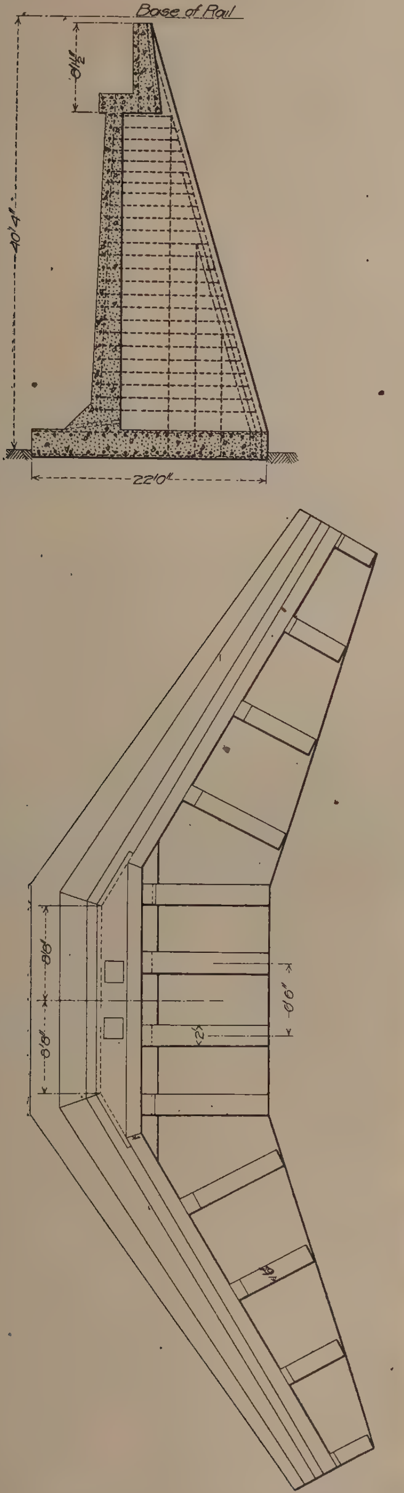
All bridges on the line are founded either on rock or piles. The footings are started 1 ft. below the pile tops and are carried up to 4 in. above the top before any reinforcing bars are used, thus forming a 16-in. cap of plain concrete, in which the piles are imbedded 1 ft.

The abutments are provided with counterforts as shown in the accompanying illustration of a plan and cross-section of a typical structure. According to Mr. S. L. Morrow, office engineer of the road, from whose paper published by the Engineering Association of the South, these notes have been taken, the ratio of base to height, in abutments of this character, must be 0.5 to 0.55 in order to make the resultant of the external forces intersect the middle third of the base. In calculating the pressure due to the backing, the engineers of the Atlanta, Birmingham & Atlantic use Rankine's formula: $P = \frac{1}{6} wh^2$ where P = the total pressure on the back of the wall applied at the lower 1-3 point, w = the weight of the backing, and h = the height of the wall.

Th reinforcement in the counterforts is, according to Mr. Morrow, of great importance, since the bars in the back take practically all the bending moment. The bending moment is calculated at the base and at points one-third and two-thirds down from the top. Assuming that the horizontal pressure is one-third the vertical for any fraction of h down from the top, the resultant will be $w\ h^2$; where w is the weight of the earth, the bending moment will be $p\ h \div 3$, or $w\ h^3 \div 18$. Assuming w to equal 100 lb. per cubic foot of earth, the moment is 5.5 h^3.

Considering the buttress, together with the front wall, as a T beam, and using as its effective depth the distance from the center of the rear bars to the inner face of the front wall, and supposing the buttresses to be spaced 10 ft. apart, the bending moment for a depth of 14 ft., down from the top will be $M = 5\frac{1}{2} \times 14^3 \times 10 =$ 190920 lb. Supposing the effective depth of the beam at 14 ft. down to be 4 ft., then 2.3 sq. in. of reinforcement will be required, using a unit stress of 16,000 lb. for the steel. In addition to the above, the horizontal components of the live load and the dead load, due to the reaction of the bridge on the abutment, must be added to the bending moment. The live load is assumed at 1,000 lb. per square foot, and the re-150,920 ft. lb. Supposing the effective depth of the cific case. The above calculations are repeated for the other depths below the surface and the sectional area of steel for each point obtained. The bars should be placed well in the rear of the counterfort and the bottom ends of them hooked over the horizontal bars near the bottom of the footing course. The steel is calculated to carry the entire overturning moment because the concrete is placed in the forms in horizontal courses, and may have planes of cleavage at the points where one day's work joins another. Main counterforts are placed under each bridge bearing or point of concentrated loading. The parapet walls and face walls are treated as slabs supported by the counterforts.

The bridge seat proper receives no direct load, since the main buttresses are designed to carry the entire weight of the bridge, but it carries a portion of the overturning moment from the parapet wall and this is taken care of by lateral reinforcement. The bridge seats are heavy enough to transfer the load to the buttresses if the girders should become displaced through accident.



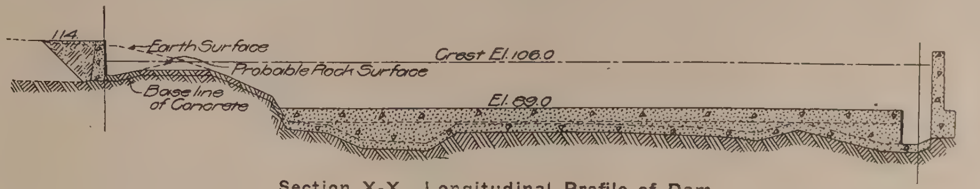
Reinforced Concrete Abutment.

The footing course is considered as a beam supported by the counterforts. The pressure is greatest near the toe and gradually decreases until it becomes a minus quantity at the back of the abutment. The footing course near the front of the abutment is therefore heavily reinforced, and the reinforcement is decreased as the back of the footing course is approached. The sketch given herewith shows the dimensions and proportions of one of the typical abutments.

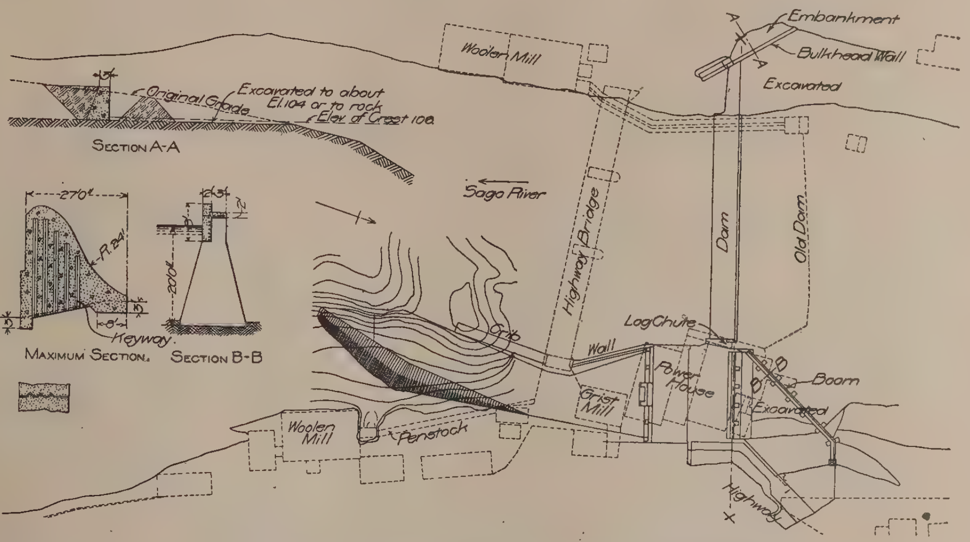
Hydraulic Development at West Buxton, Me.

There is now being installed at West Buxton, about 20 miles west of Portland, Me., a 3,000-kw. plant for the transmission of a 3-phase, 60-cycle, 30,000 volt current to the Electric Lighting Co., at Portland. It will be operated by hydraulic power developed in the Saco River and involves the construction of a dam about 300 ft. long, 33 ft. in extreme height and 28 ft. in width at the base, a 100 x 100-ft. power house, a 40 x 100-ft. dynamo house, with four 750-kw. units, turbines and other machinery required, a 150-ft. boom, a log-chute, and a 50 x 300-ft. tail race.

At the site the river has a width of 350 ft. an average depth of 3 ft., and a velocity of about 6 ft. per sec. at ordinary stages of the water. A 4-span highway bridge formerly crossed the river about 100 ft. below the present dam and slightly oblique to it, a crib dam crossed the river about 50 ft. above it and connected at the east end with an old grist mill and other buildings which occupied the site of the power house.



Section X-X. Longitudinal Profile of Dam.

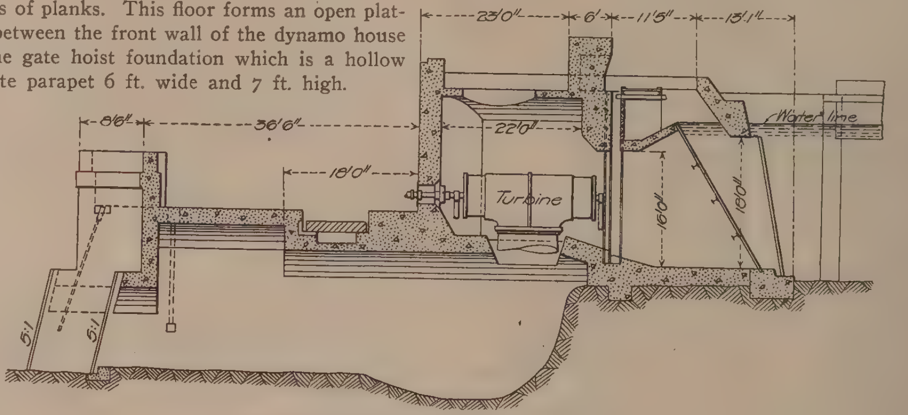


Location of Dam and Power House, with Sections.

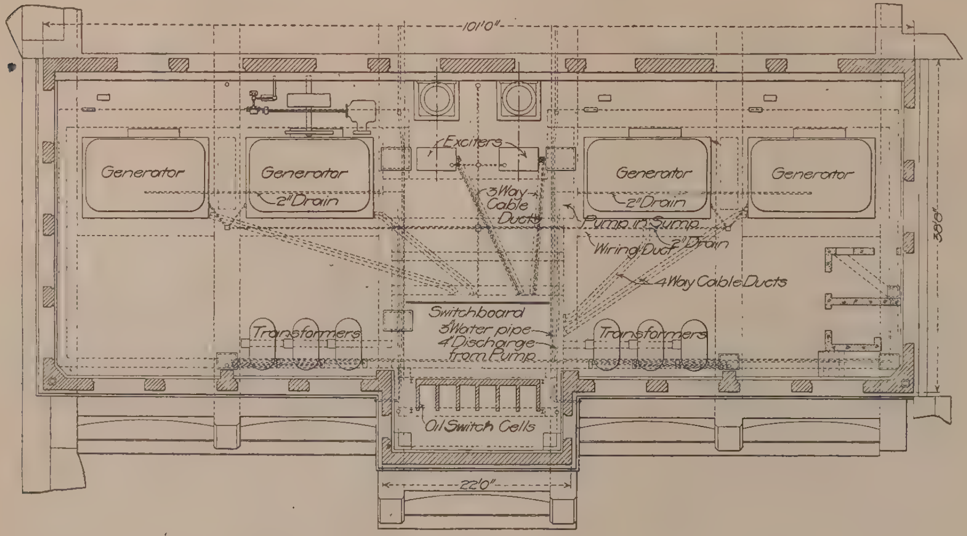
General View of Dam and Power House.

The dam is approximately perpendicular to the shore line and has a standard cross section with curved crest and ogee face downstream, a vertical face upstream, and a depressed footing or cut-off wall at both the up and downstream longitudinal edges of the foundation. The west end of the dam makes an oblique angle with a concrete abutting wall which it intersects and with which it is integral, the footings of this wall are carried down to rock and it has a maximum height of 10 ft. with a top width of 3 ft. It extends about 100 ft. upstream from the dam to intersections with the maximum flow lines of the impounded water and is carried up to a height of 8 ft. above the crest of the dam, thus concentrating all flow over the crest of the dam and protecting the bank on the downstream side. The wall was built in an open cut with 1:1 slopes and was back filled on the shore side, the river side being left unfilled and excavated near the dam to a depth of 3 ft. below the crest. At the opposite end of the dam a sluice 11 ft. wide and 2 ft. deep below the crest is built to afford a runway chute for logs and slopes rapidly downward to a point about 10 ft. beyond the lower face of the dam where it is below water level. The sluice is integral on the river side with the dam and on the shore side with the outer wall of the power house foundations. Normally, the sluice is opened and the water discharged through it somewhat reduces the depth on the crest of the dam, but provision is made for closing it if necessary by stop planks fitting recesses in the side walls near the upper end.

The power house foundations are of concrete up to a level 75 ft. above the dynamo floor, above which the structure is entirely of brick and steel except on the side towards the turbine chambers, which are separated from the dynamo room by a concrete wall extending 8 ft. above the crest. The floor of the dynamo room is 13 ft. below the crest of the dam and in order to provide for a possible flood such as was caused by an ice gorge eight years ago, the windows and doors are 7½ ft. above the floor and the walls are made reasonably tight up to that height. Water is admitted to the turbine chambers through five rectangular 16 x 16-ft. openings between the four longitudinal interior foundation walls which are extended about 23 ft. beyond the intake gate to form piers with slightly inclined cut waters and a concrete foundation on the solid rock 22 ft. below the crest of the dam. The piers support on their upstream faces a continuous reinforced concrete girder with an irregular cross section about 8 ft. deep and 7 ft. wide, having its lower surface 2 ft. below the crest of the dam to form a sort of boom to intercept any floating material and also a support for needles for closing any penstock above the gates, as well as making foundations for a future house over gates, hoists and screens. A depressed walk 2½ ft. wide and 3 ft. above the crest of the dam provides a platform from which it is easy to push the débris along the face of the boom and from which needles may be placed. About 7 ft. in the clear downstream from this girder there is a second thin horizontal girder supported on the piers and extending across the full width of the power house. It has a horizontal and inclined surface forming the bottom and one side of a trough opening into the log chute. The downstream side of the trough is vertical and is formed by horizontal planks separating it from the gates. The upstream edge of the trough is at the level of the dam crest and forms a support for the inclined rack bars 23 ft. 3 in. long and 2 in. apart on centers. The feet of these bars take bearings on a concrete footing and they are intermediately supported by three lines of equidistant horizontal I-beams. A timber platform is carried by transverse I-beams 4 ft. above the top of the trough and permits an attendant easily to float the ice which may accumulate against the masonry or rack over the edge of the trough and thence push it or allow the current in the trough to carry it down to the log sluice.



Section through Forebay and Tailrace.



Plan of Power House.

The floor of the turbine room is made with massive concrete arches without reinforcement which are 2.5 ft. thick at the crown and are carried by the 3-ft. longitudinal interior walls in the plane of the outside piers above mentioned. The tops of these walls are pitched both ways from the centers to the springing line so as to give radial surfaces for the skewback bearings. The footings of these walls are carried down 39 ft. below the crest of the dam or 1 ft. below the level of the main excavation. The roof over the turbine room is similar in construction to its floor, but the arches are only 1 ft. thick at the crown and are pierced over the centers of the turbines with large circular holes closed with doors made with two crossed courses of planks. This floor forms an open platform between the front wall of the dynamo house and the gate hoist foundation which is a hollow concrete parapet 6 ft. wide and 7 ft. high.

The entire area of the dynamo room is commanded by a traveling crane of 34½ ft. span, and 15-tons capacity, with its rails 5 ft. clear of the lower ends of the 20-in. roof beams 7 ft. 8 in. apart on centers which are pitched about 1 in 36 and carry a continuous 4-in. slab of concrete, reinforced by No. 10 expanded metal with 3-in. meshes and covered with tar and gravel.

The intakes are closed by vertical wooden gates made with 4-in. horizontal planks with pairs of 8 x 10-in. vertical lifting beams bolted, keyed and X-braced to them and provided with cast-iron racks engaging pinions operated by hand from the deck above. Many logs are run down the river and are diverted from the power house by the main boom which extends from the log sluice to the river bank at a point about 110 ft. upstream, thus making an angle of about 45 deg. with the face of the power house and facilitating the movement of logs and other drifting material to the sluice. It is a horizontal concrete girder with a T-shaped cross section 8 ft. deep and 5 ft. wide with vertical and horizontal webs respectively 2 ft. and 1 ft. in thickness. The vertical web is reinforced by 19 rods with areas of 1 sq. in. spaced 5 in. apart lapped 2 ft. at joints and located 2 in. from the downstream face of the beam. The horizontal web is reinforced by six bars each with an area of .62 sq. in. spaced 6 in. apart, lapped 13 in. at joints and located 2 in. above its lower surface and forms a walk. The booms are supported on concrete piers, 4 ft. thick, with both sides battered 4:1 and nearly 23 ft. apart on centers. The girder is made continuous with three-panel lengths and butt joints for expansion on the center line of the center pier, the river abutment, and the last pier at the shore side.

The existing dam over 100 years old was made with cribs filled with stone and although in excellent preservation was so leaky that all the silt and sediment had washed through it from the pond above. It was made tight with sand bags put in place by divers and the crest was raised 5 ft. with flash boards supported on triangular wooden frames, the west end being torn out to take the flow. A low earth dam or dyke sheeted on the lower side, was built nearly across the river below the site of the new dam and the river diverted to a channel near the west bank by a cofferdam 200 ft. long on the east side of the channel parallel to the shore line and connecting the old dam and the dike below. It was made with timber cribs, 15 ft. high, 12 ft. long and 16 ft. wide floated to place, filled with sand and sheeted with 3-in. tongue and groove vertical planks. The area between the dams was drained and kept dry with a single pulsometer and a 6-in. steam pump. The surface of the granite rock was found smooth and regular, but on account of the deep seams it contained was excavated with steam drills and dynamite to a depth of 4 to 8 ft. for the footings of the new dam.

A concrete platform 33 ft. above the river bottom was built on falsework trestle bents at the level of the highway on the east bank of the river. Stone from the excavation was broken in a Gates crusher and stored in a 1,000-yd. pile on the opposite side of the road from the plaftorm, where sand and gravel were also delivered by wagons. Cement was stored in adjacent buildings and all of the material was delivered by wheel-barrows to the center of the platform where they were measured and chuted through trap doors to two Smith mixers under the platform which delivered the concrete to 1-yd. bottom dump steel buckets on flat cars on a 2-ft. track on a service platform about 400 ft. long and 16 ft. above the bottom of the river. The concrete was delivered to six guyed derricks with 5-ton, 60-ft. booms which commanded the entire length of the dam and handled the forms and all materials. They were operated by Lidgerwood double drum engines and handled a maximum of about 200 yd. of concrete daily.

The concreting was carried on without interruption during the coldest weather and when the temperature was as low as minus 47°. The only precautions taken were to mix the concrete with hot water and to soak the broken stone in a hot water tank large enough for two 1-yd. skips and heated by exhaust steam from the steam engine and live steam from the hoisting engine boilers. Although the sand was used cold, the concrete was so hot when first mixed that sometimes the men could scarcely walk in it with rubber boots. It was covered at night with tarpaulins and in the morning was found still moist and unfrozen.

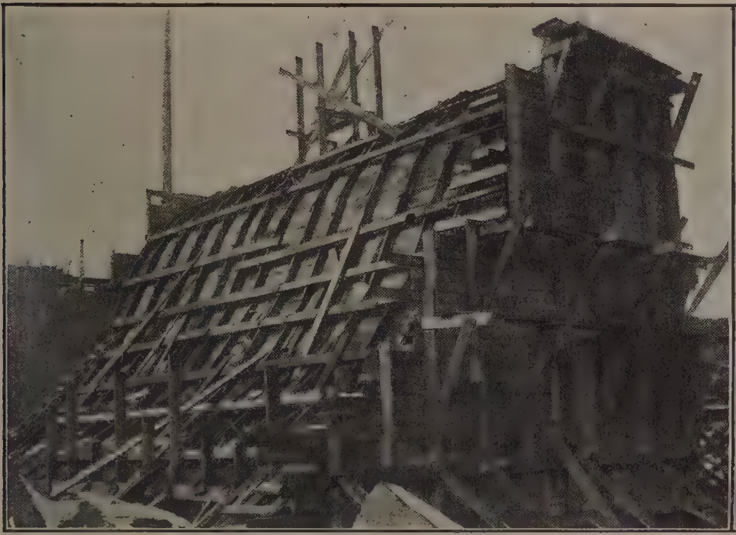
The dam was made in alternate sections 40 ft. long, bonded together with four vertical triangular 12x12-in. keys 18 in. apart in the clear. They terminated 2 ft. below the upper surface of the dam.

Derrick stones up to 1 yd. in volume were bedded in the concrete and formed about 30 per cent. of its mass. Care was taken in filling the molds to complete a horizontal course over the whole surface each day, a requirement which necessitated the men sometimes working from 12 to 14 hr.; corresponding heights of from 3 to 8 ft. a day were secured according to whether the work was at the base or the top of the dam. Successive courses were bonded together by large stones imbedded in the surface so as to project half-way above the top of the lower course and tooth with the upper course. The forms were built of 2-in. square edged dressed pine planks and were not interchangeable, being knocked down as each one was stripped and rebuilt for the next.

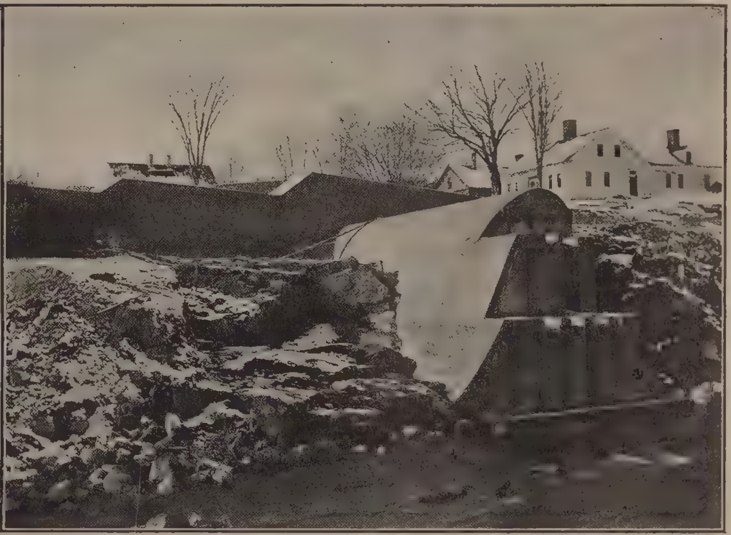
The contract was awarded Aug. 20, 1906, and work at the site was commenced Sept. 1, and has been carried on continuously ever since and the concrete work is now completed with the exception of two 40-ft. sections of the dam at the waste channel. Conditions have been favorable and low water has prevailed except during the spring freshet, when the discharge amounted to about 12,000 cu. ft. per second. The principal quantities include 150,000 ft. board measure of lumber in the forms, 25,000 cu. yd. of excavation, and 11,000 yd. of concrete made with Atlas and Vulcanite Portland cement. About 400 men were employed on the work during the fall, until it was seen that it would be impossible to complete the dam before the ice went out in the spring, and at Christmas the force was reduced to 200 men and maintained at that figure during the winter. J. G. White & Co. are the contractors, Mr. A. S. Crane, chief hydraulic engineer, and Mr. C. H. Nichols, superintendent of construction.

The Loring N. Farnum Co. are subcontractors for the dam and power house.

The turbines are supplied by the S. Morgan Smith Co.; the electrical apparatus by the General Elec. Co., and the water wheel governors by the Lombard-Replogle Co.



Mould for One Section of Dam.



Offsets and Recesses for Bonding Sections.

Power Plant of a Paper Mill.

What electricity will do in improving conditions in paper production is well shown in the new works of the Willamette Pulp & Paper Co., at Oregon City. The company's first mill was built at a 25-ft. fall in the Willamette River. The location was not particularly good for manufacturing and since the development of electric power transmission and shop operation it has become possible to build the new mill 1,000 ft. from the falls and drive it by motors receiving current from a turbine-driven unit at the old mill. In this way it has become possible to develop 750 h.-p. additional at the falls and to use it at the most advantageous site. The turbine is rated at 1,000 h.-p. and was built by the Platt Iron Works; it is direct-connected to a 600-kw., 3-phase, 600-volt General Electric generator, and power is transmitted directly at the generator voltage. The machinery in the mill is driven mainly on the group system by induction motors. A 200-h.-p. motor drives a 12 x 13-in. chipper, a chip separator, a saw-dust conveyor and a chip elevator. A 200-h.-p. motor drives three pumps and four beaters; owing to the large starting effort required for the beaters, a friction clutch is inserted in the line shaft so that the motor can come up to speed without load and then take the load gradually by means of the clutch. A 100-h.-p. motor drives two chest agitators and three pumps, and another motor of equal rating runs the Jordan engine. A 50-h.-p. motor drives four wet machines and three Decker machines. Motor operation is not used with the 152-in. paper machine, since the drying cylinders require a large amount of steam for warming purposes and a 650-h.-p. non-condensing engine furnishes the most economical operation, as the exhaust can be used for warming.

A Horizontal Expansion Joint has been provided between the top of the Wachusett dam and the granolithic surfacing above it, which averages 5½ in. in thickness. This was done by covering the top of the dam with powdered mica, which prevented the adhesion of the two surfaces. The granolithic pavement is in squares about 9 ft. 9 in. on a side, with ½-in. joints filled with asphaltum.

Report of the British Joint Committee on Reinforced Concrete.

In October, 1905, the Royal Institute of British Architects invited a number of leading organizations and government departments interested in reinforced concrete to appoint representatives on a joint committee to draw up rules for the guidance of architects for the use of reinforced concrete. Up to that time, there had been no authoritative rules prepared in the country, owing to the practical prohibition of reinforced concrete for complete buildings by the ordinary building regulations. Only railway and dock companies and other bodies exempt from these restrictions had been able to avail themselves of this method of construction. The committee was made up of the following members: Royal Institute of British Architects, Sir Henry Tanner, chairman, Messrs. T. Walmisley, William Dunn, Max Clarke and H. D. Searles-Wood; District Surveyors' Association, Messrs. Thomas H. Watson and E. D. Drury; Institute of Builders, Messrs. B. I. Greenwood and Frank May; Municipal and County Engineers' Association, Messrs. A. E. Collins and J. W. Cockrill; War Office, Col. C. B. Mayne, vice-chairman, and Major E. M. Paul; Admiralty, Mr. C. H. Colson; special members, Prof. W. C. Unwin, vice-chairman, Mr. Charles F. Marsh and Col. F. Winn. The aim of this committee was to produce a good working guide, laying down the necessary conditions and stating safe rules for a proper disposition of the parts of a reinforced concrete structure. Previously every specialist in the country made his own rules and the margin of safety was occasionally cut too fine. In preparing its rules, the committee endeavored to avoid giving any preference to patented systems and materials, and confined itself to stating principles for all kinds of structures reinforced with ordinary bars. The report reads as follows:

1. Reinforced concrete is used so much in building and engineering construction that a general agreement on the essential requirements of good work is desirable. The proposals which follow are intended to embody these essentials, and to apply generally to all systems of reinforcement.

Good workmanship and materials are essential in reinforced concrete. With these and good design structures of this kind appear to be trustworthy. It is essential that the workmen employed should be skilled in this class of cons[illegible] tion. Very careful superintendence is [illegible] during the execution of the work in [illegible]

(*a*) The quality, testing and [illegible] materials.

(*b*) The sizes and positions of the reinforcements.

(*c*) The construction and removal of centering.

(*d*) The laying of the material in place and the thorough punning of the concrete to ensure solidity and freedom from voids.

If the metal skeleton be properly coated with cement, and the concrete be solid and free from voids, there is no reason to fear decay of the reinforcement in concrete of stone, gravel, cinder, coke-breeze, etc., made with clean, fresh water.

2. The By-Laws regulating building in this country require external walls to be in brick, or stone, or concrete of certain specified thicknesses. In some places it is in the power of the local authorities to permit a reduced thickness of concrete when it is strengthened by metal; in other districts no such power has been retained. We are of opinion that all By-Laws should be so altered as to expressly include reinforced concrete amongst the recognized forms of construction.

A section should be added to the By-Laws declaring that when it is desired to erect buildings in reinforced concrete complete drawings showing all details of construction and the sizes and positions of reinforcing bars, a specification of the materials to be used and proportions of the concrete, and the necesary calculations of strength based on the rules contained in this report, signed by the person or persons responsible for the design and execution of the work, shall be lodged with the local authority.

3. (*a*) Floors, walls and other constructions in steel and concrete formed of incombustible matetials prevent the spread of fire in varying degrees according to the composition of the concrete, the thickness of the parts, and the amount of cover given to the metal.

(*b*) Experiment and actual experience of fires show that concrete in which limestone is used for the aggregate is disintegrated, crumbles and loses coherence when subjected to very fierce fires, and that concretes of gravel or sandstones also suffer, but in a rather less degree. The smaller the aggregate the less the injury. The metal reinforcement in such cases generally retains the mass in position, but the strength of the part is so much diminished that it must be renewed. Concrete in which coke-breeze, cinders or slag forms the aggregate is only superficially injured, does not lose its strength, and in general may be repaired. Concrete of broken brick suffers more than cinder concrete and less than gravel or stone concrete.

(*c*) The material to be used in any given case should be governed by the amount of fire resistance required as well as by the cheapness of, or the facility of procuring, the aggregate.

(*d*) Rigidly attached web members, loose stirrups, bent-up rods, or similar means of connecting the metal in the lower or tension sides of beams or floor slabs (which sides suffer most injury in case of fire) with the upper or compression sides of beams or slabs not usually injured are very desirable.

(*e*) For main beams a covering of 1½ to 2 in. of concrete over the metal reinforcement appears from experience in actual fires to afford ample protection to the structural parts. In floor slabs the cover required may be reduced to 1 in. All angles should be rounded or splayed to prevent spalling off under heat.

(*f*) More perfect protection to the structure is required under very high temperature, and in the most severe conditions it is desirable to cover the concrete structure with fire-resisting plastering which may be easily renewed. Columns may [illegible]overed with coke-breeze concrete, terra-cotta, [illegible] fire-resisting facing.

[illegible]*ls.*—4. Only Portland cement complying [illegible]upirements of the specification adopted by the British Engineering Standards Committee should be employed; in general the slow-setting quality should be used. Every lot of cement delivered should be tested, and in addition the tests for soundness and time of setting, which can be made without expensive apparatus, should be applied frequently during construction. The cement should be delivered on the works in bags or barrels bearing the maker's name and the weight of the cement contained.

5. The sand should be composed of hard grains of various sizes up to particles which will pass a quarter-inch square mesh, but of which at least 75 per cent. should pass ⅛-in. square mesh. Fine sand alone is not so suitable, but the finer the sand the greater is the quantity of cement required for equal strength of mortar. It should be clean and free from ligneous, organic or earthy matter. The value of a sand cannot always be judged from its appearance, and tests of the mortar prepared with the cement and the sand proposed should always be made. Washing sand does not always improve it, as the finer particles which may be of value to the compactness and solidity of the mortar are carried away in the process.

6. The aggregate, consisting of gravel, hard stone, or other suitable material, should be clean and angular, varied in size as much as possible between the limits of size allowed for the work. In all cases material which passes a sieve of a ¼-in. square mesh should be reckoned as sand. the maximum allowable size is usually ¾ in. The maximum limit must always be such that the aggregate can pass between the reinforcing bars and between these and the centering. The sand should be separated from the gravel or broken stone by screening before the materials are measured.

7. In all cases the proportions of the cement, sand and aggregate should be separately specified in volumes.

As the strength and durability of reinforced concrete structures depend mostly on the concrete being properly proportioned, it is desirable that in all important cases tests should be made as described herein with the actual materials that will be used in the work before the detailed designs for the work are prepared.

In no case should less dry cement be added to the sand when dry than will suffice to fill its interstices, but subject to that the proportions of the sand and cement should be settled with reference to the strength required, and the volume of mortar produced by the admixture of sand and cement in the proportions arranged should be ascertained.

The interstices in the aggregate should be measured and at least sufficient mortar allowed to each volume of aggregate to fill the interstices and leave at least 10 per cent. surplus.

For ordinary work a proportion of one part cement to two parts sand will be found to give a strong, practically watertight mortar, but where special watertightness or strength is required the proportion of cement must be increased.

The amount of cement added to the aggregate should be determined on the work by weight. The weight of a cubic foot of cement for the purpose of proportioning the amount of cement to be added may be taken at 90 lbs.

8. The metal used should be steel having the following qualities:—

(*a*) An ultimate strength of not less than 60,000 lb. per square inch.

(*b*) An elastic limit of not less than 50 per cent., or more than 60 per cent. of the ultimate.

(*c*) An elongation of not less than 22 per cent. in the lengths stated below.

(*d*) It must stand bending cold 180° to a diameter of the thickness of pieces tested without fracture on outside of bent portion.

In the case of round bars the elongation should not be less than 22 per cent., measured on a gauge-length of eight diameters. In the case of bars over one inch in diameter the elongation may be measured on a gauge-length of four diameters, and should then be not less than 27 per cent. For other sectional material the tensile and elongation tests should be those prescribed in the British Standard Specification for Structural Steel.

Before use in the work the metal must be clean and free from scale or loose rust. It should not be oiled or painted, but a wash of thick Portland cement grout is desirable.

Welding should in general be forbidden; if it is found necessary, it should be at points where the metal is least stressed, and it should never be allowed without the special sanction of the architect or engineer responsible for the design.

The reinforcement ought to be placed and kept exactly in the positions marked on the drawings, and, apart from any consideration of fire resistance, ought not to be nearer the surface of the concrete at any point than 1 in. in beams and ½ in. in floor slabs or other thin structures.

9. In all cases the concrete should be mixed in small batches and in accurate proportions, and should be laid as rapidly as possible.

When the materials are mixed by hand they are to be turned over and thoroughly mixed on a clean platform until the color of the cement is uniformly distributed over the aggregate.

Whenever practicable the concrete should be mixed by machinery.

10. The thickness of loose concrete that is to be punned should not exceed 3 in. before punning, especially in the vicinity of the reinforcing metal. Special care is to be taken to ensure perfect contact between the concrete and the reinforcement, and the punning to be continued till the concrete is thoroughly consolidated. Each section of concreting should be as far as possible completed in one operation; when this is impracticable, and work has to be recommenced on a recently laid surface, it is necessary to wet the surface; and where it has hardened it must be hacked off, swept clean, and covered with cement grout. Work should not be carried on when the temperature is below 34° Fahr. The concrete when laid should be protected from the action of frost, and shielded against too rapid drying from exposure to the sun's rays or winds, and kept well wetted. All shaking and jarring must be avoided. The efficiency of the structure depends chiefly on the care with which the laying is done.

The amount of water to be added depends on the temperature at the time of mixing, the materials, and the state of these, and other factors, and no recommendation has therefore been made. Sea-water should not be used.

11. The centering must be of such dimensions, and so constructed, as to remain rigid and unyielding during the laying and punning of the concrete. It must be so arranged as to permit of easing and removal without jarring the concrete. Provision should be made wherever practicable for splaying or rounding the angles of the concrete. Timber when used for centering may be advantageously limewashed before the concrete is deposited.

12. The time during which the centres should remain up depends on various circumstances, such as the dimensions or thickness of the parts of the work, the amount of water used in mixing, the state of the weather during laying and setting, etc., and must be left to the judgment of the person responsible for the work. The casing for columns, for the sides of beams, and for the soffits of floor slabs not more than 4 ft. span must not be removed under eight days; soffits of beams and of floors of greater span should remain up for at least fourteen days, and for large span arches for at least twenty-eight days. The centering of floors in buildings which are not loaded for some time after the removal of

same may be removed in a short time; the centering for structures which are to be used as soon as completed must remain in place much longer. If frost occurs during setting, the time should be increased by the duration of the frost.

13. Before the detailed designs for an important work are prepared, and during the execution of such a work, test pieces of concrete should be made from the cement, sand and aggregate to be used in the work, mixed in the proportions specified. These pieces should be either cubes of not less than 4 in. each way, or cylinders not less than 4 in. diameter, and of a length not less than the diameter. They should be prepared in moulds, and punned as described for the work. Not less than four cubes or cylinders should be used for each test, which should be made twenty-eight days after moulding. The pieces should be tested by compression, the load being slowly and uniformly applied. The average of the results should be taken as the strength of the concrete for the purposes of calculation, and in the case of concrete made in proportions of 1 cement, 2 sand, 4 hard stone, the strength should not be less than 2,400 lb. per square inch.

Loading tests on the structure itself should not be made until at least two months have elapsed since the laying of the concrete. The test load should not exceed one and a half times the accidental load. Consideration must also be given to the action of the adjoining parts of the structure in cases of partial loading. In no case should any test load be allowed which would cause the stress in any part of the reinforcement to exceed two-thirds of that at which the steel reaches its elastic limit.

Methods of Calculation.—1. In designing any structure there must be taken into account:—

(*a*) The weight of the structure.

(*b*) Any other permanent load, such as flooring, plaster, etc.

(*c*) The accidental load. By "accidental" load is meant the imposed load additional to the weight of the structure for which the structure is calculated.

(*d*) In some cases also an allowance for vibration and shock.

Of all probable distributions of the load, that is to be assumed in calculation which will cause the greatest straining action.

The weight of the concrete and steel structure may be taken at 150 lb. per cubic foot.

In structures subjected to very varying loads and more or less vibration and shock, as, for instance, the floors of public halls, factories, or workshops, the allowance for shock may be taken equal to half the accidental load. In structures subjected to considerable vibration and shock, such as floors carrying machinery, the roofs of vaults under passage ways and courtyards, the allowance for shock may be taken equal to the accidental load.

In the case of columns or piers in buildings, which support three or more floors, the load at different levels may be estimated in this way. For the part of the roof or top floor supported, the full accidental load assumed for the floor and roof is to be taken. For the next floor below the top floor 10 per cent. less than the accidental load assumed for that floor. For the next floor 20 per cent. less, and so on to the floor at which the reduction amounts to 50 per cent. of the assumed load on the floor. For all lower floors the accidental load on the columns may be taken at 50 per cent. of the loads assumed in calculating those floors.

2. Spans may be taken as follows: For beams the distance from centre to centre of bearings. For slabs supported at the ends, the clear span + the thickness of slab. For slabs continuous over more than one span the distance from centre to centre of beams.

3. In the most ordinary case of a uniformly distributed load of w lbs. per inch run of span the bending moments will be as follows:

(*a*) Beam or slab simply supported at the ends. Greatest bending moment at centre of span of l inches is equal to $w\,l^2/8$ inch-lbs.

(*b*) Beam continuous over several spans, or encastré or fixed in direction at each end. The greatest bending moments are at the ends of the span, and the beam should be reinforced at its upper side near the ends. If continuity can be perfectly relied on, the bending moment at the centre of the span is $w\,l^2/24$, and that over the supports $-\,w\,l^2/12$. If the continuity is in any way imperfect, the bending moment at the centre will in general be greater, and that at the supports less, but the case is a very indefinite one. It appears desirable that generally in building construction the centre bending moment should not be taken less than $w\,l^2/12$. The bending moment at the ends depends greatly on the fixedness of the ends in level and direction. When continuity and fixing of the ends, whether perfect or imperfect, is allowed for in determining the bending moment near the middle of the span, the beam or slab must be designed and reinforced to resist the corresponding bending moments at the ends. When the load is not uniformly distributed the bending moments must be calculated on the ordinary statical principles.

4 The internal stresses are determined, as in the case of a homogeneous beam, on these approximate assumptions:

(*a*) The coefficient of elasticity in compression of stone or gravel concrete, not weaker than 1:2:4, is treated as constant and taken at one-fifteenth of the coefficient of elasticity of steel: Coefficient for concrete $= E_c =$ 2,000,000 lb. per square inch; coefficient for steel $= E_s =$ 30,000,000 lb.; $E_s \div E_c = 15$. It follows that at any given distance from the neutral axis, the stress per square inch on steel will be fifteen times as great as on concrete.

(*b*) The resistance of concrete to tension is neglected, and the steel reinforcement is assumed to carry all the tension.

(*c*) The stress on the steel reinforcement is taken as uniform on a cross-section, and that on the concrete as uniformly varying.

5. If the concrete is of such a quality that its crushing strength is 2,400 to 3,000 lb. per square inch after twenty-eight days, and the steel has a tenacity of not less than 60,000 lb. per square inch, the following stresses may be allowed:

Concrete, in compression in beams subjected to bending, 600 lb. per square inch; concrete in columns under simple compression, 500 lb. per square inch; concrete in shear in beams, 60 lb. per square inch; adhesion of concrete to metal, 100 lb. per square inch; steel in tension, 15,000 to 17,000 lb. per square inch.

It is desirable that the reinforcing rods should be so designed that the adhesion is sufficient to resist the shear between the metal and concrete. Precautions should in every case be taken by splitting or bending the rod ends, or otherwise to provide additional security against the sliding of the rods in the concrete.

When the proportions of the concrete differ from those stated above the stress in compression allowed in beams may be taken at one-fourth, and that in columns at one-fifth of the crushing stress of cubes of the concrete of sufficient size at twenty-eight days after gauging. If stronger steel is used than that stated above, the allowable tensile stress may be taken at one-half the stress at the yield point of the steel.

Let b be the width and d the effective depth of the beam in inches.

$A = bd$ the area of cross-section.

$m = E_s/E_c$ the ratio of the coefficients of elasticity of steel and concrete.

$M =$ bending moment at the section considered, in inch-pound units.

$t =$ tensile stress in metal in pounds per square inch.

$c =$ compressive stress in concrete per square inch.

$z =$ distance of resultant thrust in concrete from compressed edge of beam in inches.

$kd =$ distance of neutral axis from compressed edge in inches.

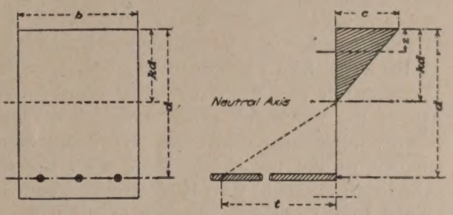
$A_c = kbd =$ area of concrete in compression in square inches.

$A_t =$ area of metal in tension in square inches.

$p = A_t/bd$ the ratio of section of metal to section of concrete.

$l =$ span in inches.

$w =$ load per inch run of span.



(*a*) *Beams of Rectangular Section with Single Reinforcement.*—In a homogeneous beam the stresses are proportional to the distances from the neutral axis. In a discrete beam, such as a beam of concrete and steel, on account of the greater rigidity of steel, at a given distance from the neutral axis the stress in the steel will be m times as great as in concrete. Hence—

$$\frac{mc}{t} = \frac{kd}{d\,(1-k)} = \frac{k}{1-k}$$

But equating the total tension and compression

$$\tfrac{1}{2}\,cbkd = pbdt$$
$$ck = 2pt.$$

Replacing c in terms of t

$$k^2 \div m\,(1-k) = 2p$$
$$k = \sqrt{(p^2m^2 + 2pm)} - pm.$$

Thus for $m = 15$

$p = 0.007,\ 0.010,\ 0.015,\ 0.020.$

$k = 0.365,\ 0.417,\ 0.483,\ 0.530.$

That is, the neutral axis is lower as the amount of reinforcement is greater, and passes the half depth for 2 per cent. of reinforcement.

The distance of the resultant thrust from the compressed edge is $z = \tfrac{1}{3}kd$.

Equating the moments of resistance to the bending moment,

$$M = A_t t\,(d - \tfrac{1}{3}kd) = \tfrac{1}{2}A_c c\,(d - \tfrac{1}{3}kd)$$

$$t = \frac{M}{A_t d\,(1 - \tfrac{1}{3}k)} = \frac{M}{pbd^2\,(1 - \tfrac{1}{3}k)}$$

$$c = \frac{2M}{A_c d\,(1 - \tfrac{1}{3}k)} = \frac{2M}{kbd^2\,(1 - \tfrac{1}{3}k)}$$

The shearing stresses and tensions near the ends of the beam are usually resisted by stirrups or inclined steel bars, and it is always desirable to bend upwards near the supports one or more of the reinforcing bars when the reduced bending moments at the ends permit of so doing. Stirrups or rigidly attached web members or inclined bars should be provided in all cases where the average shearing stress on a vertical section of the beam exceeds 60 lb. per square inch of the section. A theoretical determination of the section required for these would be very difficult. If the simple case is taken of a uniformly loaded beam, supported at the ends with horizontal steel tension bars not bent up at the ends, the adhesion between concrete and steel which is required may be found thus: The difference of tension in 1-ft. length of bars at the end of the span will be the tangential force between steel and concrete in that distance. The bending moment at the end is 0, and at 1 ft. from the end $6w\ (l - 12)$ inch-pounds, where w is the load per inch run. Hence the increment of tension between the end and 1 ft. from the end is

$$6w\ (l - 12) \div d\ (1 - \tfrac{1}{3}\ k)\ \text{lb.}$$

If Ψ is the total perimeter of the reinforcing bars, the adhesion stress is $w\ (l - 12) \div 2\ \Psi\ d\ (1 - \tfrac{1}{3}\ k)$ lb. per square inch.

(*b*) *Beams of T Section with Single Reinforcement.*—In designing T beams where the upper flange forms a floor the thickness d_1 of this wall first be ascertained by considering the part between two ribs as a slab, having its own reinforcing bars transverse to the rib. The whole of this cannot in general be considered to form part of the upper flanges of the T beams. The width b_1 of the upper flange may be assumed to be not greater than one-third the span of the beams, or than three-fourths of the distance from centre to centre of the reinforced ribs. There is no satisfactory theoretical determination of the precise amount of the floor slab acting with the web. The depth d should then be determined with reference to the stiffness required in the floor. In general, d is from one-twelfth to one-eighteenth of the span.

Two cases arise according as the thickness of flange is greater or less than kd, the distance from the neutral axis to the compressed edge. In the former case (d_1 greater than kd) the rules under (*a*) apply if b_1 is substituted for b, and $A = b_1d_1 + b\ (d - d_1)$ for bd. The equations then become

$$mc \div t = k \div (1 - k)$$

$$k = \sqrt{\left(\frac{2pAm}{b_1d} + \frac{p^2A^2m^2}{b_1^2d^2}\right)} - \frac{pAm}{b_1d}$$

$$= \sqrt{\left(\frac{2A_tm}{b_1d} + \frac{A_t^2m^2}{b_1^2d^2}\right)} - \frac{A_tm}{b_1d}$$

$$z = \tfrac{1}{3}kd$$

$$t = \frac{M}{A_td(1 - \tfrac{1}{3}k)} = \frac{M}{pAd(1 - \tfrac{1}{3}k)}$$

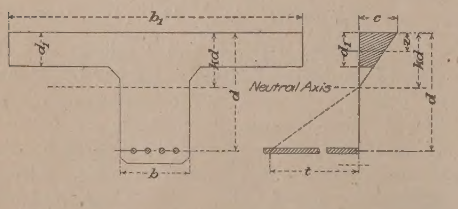
$$c = \frac{2M}{A_cd(1 - \tfrac{1}{3}k)} = \frac{2M}{kb_1d(1 - \tfrac{1}{3}k)}$$

where $pA = A_t$ the section of reinforcement. The increment of tension in 1 ft. length at the end of the beam and the adhesion stress is the same as in (*a*).

When d_1 is less than kd the small compression in the web between d_1 and kd may be neglected.

Let, as before, the whole area of section $= A = b_1d_1 + b(d - d_1)$, and pA be the area of reinforcement.

$$mc \div t = k \div (1 - k).$$



The mean compressive stress on the flange is

$$\tfrac{1}{2}\left\{c + c\frac{kd - d_1}{kd}\right\} = \frac{c}{2}\,\frac{2kd - d_1}{kd}.$$

Equating the total tension and compression,

$$A_tt = pAt = \tfrac{1}{2}b_1d_1c\ (2kd - d_1) \div kd$$

$$kd = \frac{b_1d_1^2 + 2pAmd}{2b_1d_1 + 2pAm} = \frac{b_1d_1^2 + 2A_tmd}{2b_4d_1 + 2A_tm}.$$

$$\text{But } z = \frac{d_1}{3}\ \frac{3kd - 2d_1}{2kd - d_1}$$

Equating the moments

$$M = A_tt(d - z) = pAt\ (d - z) =$$
$$\tfrac{1}{2}b_1d_1c\ (2kd - d_1)\ (d - z) \div kd$$
$$t = M \div pA(d - z)$$
$$c = 2Mkd \div b_1d_1\ (2kd - d_1)\ (d - z).$$

It may be useful also to point out that the area of reinforcement for a given value of c/t is

$$A = pA = \frac{c}{t}\ \frac{b_1d_1\ (2kd - d_1)}{2kd}.$$

(*c*) *Slabs Supported on More Than Two Sides.*—It does not appear that there is either a satisfactory theory or trustworthy experiments from which the strength of rectangular slabs supported or fixed on all four edges can be determined.

(*a*) *Short Columns Axially Loaded.*—The reinforcement of columns should in general amount to at least 0.8 per cent. of the gross cross-section. The liability to bending of the longitudinal reinforcing bars greatly weakens the column, and should be prevented by steel binding bars. Some theoretical considerations would indicate that cross-binding is required at points not further apart than twenty-four times the least lateral dimension of the reinforcing rods. But further experiment shows that still closer cross-binding, or, better, spiral binding, greatly increases the strength of the column.

(M. Considère recommends that the distance between the coils of the spiral should not exceed from 1/10 to 1/7 of the diameter of the spiral. In the case of piles subjected to longitudinal shock in driving there are special reasons for decreasing the distance between the cross-binding near the ends.)

If the load is strictly axial the stress is uniform on cross-sections. Let A_c be the cross-section of the column (including the reinforcement), and A the equivalent section as defined below, a the section of logitudinal reinforcing bars, P the load on the column in pounds. Let c be the stress on the concrete, and t that on the steel, the ratio of the coefficients of elasticity being m.

$$c = \frac{P}{A_c + (m - 1)a} = \frac{P}{A}$$

$$t = \frac{mP}{A_c + (m - 1)a} = \frac{mP}{A}.$$

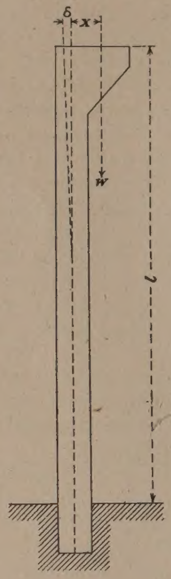
It appears that c may be taken $= 500$ lb. per square inch, $t = 7{,}500$ lb. per square inch, and $E_s/E_c = m = 15$.

When the stress on the concrete is not greater than 500 lb. per square inch, lateral bending of the column as a whole is not to be feared if the ratio of length to the least lateral dimension is not greater than 18.

(*b*) *Columns Eccentrically Loaded.*—If a column initially straight is loaded eccentrically, as when a beam rests on a bracket attached to the column, it may be regarded as fixed at the base and free at the loaded end. Then it must bend in the plane passing through the load, the deflection at the top being δ. Let x be the eccentricity of the load measured from the centre of the column when straight. Then the bending moment at the base of the column is $W\ (\delta + x)$. But it is known that δ will be small compared with x, provided that W is small compared with $2EI/l^2$, and this will be the case in such conditions as are likely to occur in designing concrete columns. Then the bending moment may be taken as Wx, and the stress at the base of the column, treating it as homogeneous, will be

$$f = W\left\{\frac{1}{A} \mp \frac{x}{Z}\right\}$$

very nearly, where A is the whole section of the column and Z the modulus of the section relatively to an axis through the centre of gravity and at right angles to the plane of bending.



In dealing with reinforced columns which are not nomogenous, it is convenient to substitute for the actual section of the column what may be termed the equivalent section, or section of concrete equivalent in resistance to the actual column. If A_c is the area of section of the column (including the area of reinforcement) and a is the area of reinforcement, then the equivalent section is

$$A = A_c + (m - 1)a.$$

If h is the depth of the section in the plane of bending, the moment of inertia relatively to the neutral axis can be expressed in the form $I = nAh^2$, and the section modulus in the form $Z = 2nAh$.

It is desirable in columns that there should be no tension, and generally when the vertical load is considerable there is none. Cases in which the eccentricity is so great that there is tension must be treated by the methods applicable to beams if it is made a condition that the steel carries all the tension. In the following cases it is assumed that there is no tension.

Case I.—Column of Circular Section, Reinforcements Symmetrical and Equidistant from the Neutral Axis. Let m be the ratio E_s/E_c of the coefficients of elasticity of steel and concrete, A_c the cross section of the column in square inches, a the area of reinforcement in square inches, h the diameter of the column, h_t the distance between the reinforcing bars perpendicular to the neutral axis. Then the equivalent section is

$$A = A_c + (m - 1)a$$

and the modulus of the section is

$$Z = \tfrac{1}{8}A_ch + \tfrac{1}{2}\ (m - 1)a\ h_t^2 \div h$$

The stress at the edges of the section can then be calculated by the general equation

$$f = W\left\{\frac{1}{A} \mp \frac{x}{Z}\right\}$$

where x is the eccentricity of the load in inches and W the load in pounds. The greater value of f must not exceed the safe stress stated above.

Case II.—Rectangular Section with Reinforcement Symmetrical and Equidistant from the Neutral Axis. Using the same notation as in the last case, h being now the depth of the section in the plane of bending, the section modulus is

$$Z = \tfrac{1}{6}A_c h + \tfrac{1}{2}\ (m - 1)a\ h_t^2 \div h$$

and the stresses are given by the same equation as in the previous case.

Case III.—Column of Circular Section with Reinforcing Bars arranged in a Circle.—Using the same notation as in Case I, h_t being the diameter of the circle of reinforcing bars, the section modulus is

$$Z = \tfrac{1}{8}\ A\ h + \tfrac{1}{4}\ (m - 1)a\ h_t^2 \div h,$$

and the stresses are given by the same equation as in Case I.

(*c*) *Long Columns axially Loaded.*—For columns more than 18 diameters in length there is risk of lateral buckling of the column as a whole. The strength of such columns would be best calculated by Gordon's formula, but there are no experiments on long columns by which to test the values of the constants for a concrete or concrete and steel column. There does not seem, however, to be any probability of serious error if the total load is reduced in a proportion inferred from Gordon's formula to allow for the risk of buckling

Let, as before, A_c = the section of the column in inches; a = the reinforcement. Then $A = A_c + (m - 1)a$ is the equivalent section. Let n be the constant in the equation, $I = nAh^2$, and h the least transverse dimension of the column.

Then for a column fixed in direction at both ends, Gordon's formula is

$$W/Af = 1 \div (1 + l^2/cnh^2) = 1 \div (1 + K)$$

so that the column will carry less than a short column of the same dimensions in the ratio of $1 + K$ to 1, or, in other words, the column will be safe if calculated as a short column, not for the actual load, W, but for a load $(1 + K)W$.

The constant c has not been determined experimentally for reinforced long columns. But its probable value is $c = 4\pi^2\ E_c/f$, where f is the ultimate crushing stress. Putting E_c = 2,000,000 and f = 2,500, then c = 32,000. Looking at the well-understood uncertainty of the rules for long columns, very exact calculation is useless.

VALUES OF $1 + K$ FOR THREE VALUES OF n.

	Case I.	Case II.	Case III.
l/h	$n = 0.098$	$n = 0.075$	$n = 0.0646$
20	1.13	1.17	1.19
25	1.20	1.26	1.30
30	1.29	1.38	1.44

The differences of $1 + K$ for considerable differences of n are not very great.

In the case of columns fixed at one end and rounded or unfixed at the other, $2K$ must be substituted for K. If the column is rounded at both ends, $4K$ must be substituted for K.

Rock Breaking on the Suez Canal.

Rock breaking on the Suez Canal has been done since 1902 with Lobnitz chiseling machines having 13-ton rams. The average height of fall of these rams is from 5 to 10 ft. On the average 132 blows are delivered per hour of effective rock breaking, but as the passage of ships through the canal requires the rock-breaking barge to be drawn aside 30 per cent. of the time, the actual work of the barge is 83 blows per hour of work paid to the crew. The average thickness of the rock bed shattered is 2 ft. 7½ in., and it requires about 5.4 blows per cubic yard to shatter the rock. There is a considerable range in the cost of the work, but it averages 1s. 4.1d. per cubic yard, exclusive of general charges. This does not include the cost of dredging the rock. Similar machines are being used on canal work in western New York.

The Rectification of an Auditorium Roof.

The pitched wooden roof of an auditorium is carried by five 80-ft. Howe trusses 7 ft. deep and 12 ft. apart on centers which also carry the light suspended ceiling. The top chords are made with 1-in. boards spiked together and the bottom chord is made with 2-in. and 4-in. planks. Pairs of vertical screw ended rods divide the trusses into eight 10-ft. panels which are X-braced with solid diagonals abutting at the ends on wooden angle blocks of the usual type. In the many years since the trusses were built they have sagged and shrunk until the deflection at the center panels was about 6 in., which, of course, threw the roof and ceiling badly out of alignment and induced stresses in the walls and framework which it was thought desirable to relieve.

The trusses were sound and otherwise in good condition and it was determined to adjust them without removing or destroying the roof or ceiling. The latter is attached to the trusses with scarcely any clearance below their bottom chords and the height was so great and the working space so small that the job presented many difficulties.

The plan finally adopted was simply to support each truss simultaneously at two intermediate panel points and from them to jack it up to the required height and adjust the vertical rods and diagonals at that elevation so as to retain permanently the camber, after the temporary supports were removed. The roof trusses are parallel with the proscenium arch and their lower chords are all in the same horizontal plane about 59 ft. above the auditorium floor. It was decided to support each truss at the third panel point from each end where a false-work tower 8 ft. square was built up to the bottom chord. These towers were 20 ft. apart on centers and 30 ft. from each end of the truss which projected beyond them like cantilevers. Each tower was made with four 4x8-in. vertical posts with butt joints with scabs spiked on both sides. Each face was divided into panels about 10 ft. high and X-braced between them with 2x6-in. boards nailed on. All of the ten towers are braced together by continuous horizontal struts and by occasional diagonal braces.

Three of the roof trusses in the rear of the auditorium are over the wide sloping floor of the upper gallery. The fourth truss is partly over this floor and partly over the main auditorium floor and the fifth truss is wholly over the orchestra circle at a clear height of nearly 60 ft. above the main floor. The two towers which support it are seated directly on the main floor and the latter is reinforced to carry them by temporary transverse beams under the cellar ceiling and supported on vertical shores and sills set in the cellar. A third similar parallel transverse beam is placed in the cellar to support the legs on one side of the towers for the second truss, which are also carried down to the main floor. The rear legs of the same towers are, however, supported on the balcony where they are carried through the floor and are seated on the tops of the girders just above the heads of the cast-iron columns. Part of the posts of the towers for the three rear trusses are seated in the same manner on the floor beams over the gallery columns and the remainder are seated on horizontal transverse sills supported at the front end by posts from these columns and at the rear end on longitudinal sills distributing their load over the upper foyer floor at the top of the gallery. In this way each of the shorter towers are terraced up over the inclined floor of the gallery and solid well-braced footings are in every case provided for them. The entire roof load is thus transferred to forty 4x8-in. posts which are well braced and are sufficient to carry several times the greatest loads that can possibly be imposed on them here.

The posts of each tower are capped by two 8x8-in. transverse timbers carrying in the center another pair of 8x8-in. longitudinal timbers on which are supported two pairs of short 8x8-in transverse sills close together. On each pair of upper sills there is seated an ordinary 3-in. cast-iron jack screw with a capacity of 5 tons. Space is left between the sills for the screw to move up and down and its head engages a bearing plate on a short cross timber set under the bottom chords of the roof truss. The jack screws are placed close together on opposite sides of the panel points and the four screws for each truss are simultaneously operated to raise the truss about 8 in., thus giving it a permanent camber of about 2 in. It is estimated that the total load on the 20 jack screws used for the five trusses is only about 20,000 lb., so that a very large margin of safety is provided to allow for irregularity in loading or settlement.

About 18,000 ft. of timber, board measure, has been used for the falsework and the difficulty of bringing it in and erecting it in the confined spaces without injuring the interior has been the principal trouble thus far encountered.

Book Notes.

The Association of American Portland Cement Manufacturers, Land Title Building, Philadelphia, has issued two bulletins containing information of general interest. The first, on concrete bridges, was written by Mr. George S. Webster, chief engineer of the Bureau of Surveys, Philadelphia, and describes certain features of the work of this class now being done under his direction. The second pamphlet contains two articles; the first, by Mr. H. L. Weber, is on concrete roadways, and the second, by Mr. Walter E. Hassam, is on cement concrete roads. Mr. Weber first laid concrete pavements in Richmond, Ind., in 1896, and sixteen such pieces of work have been done in that city up to the present time. The article explains the important points to be considered in laying these pavements and gives complete specifications for them. In the second article, the author explains the method of laying the pavement that bears his name and gives a number of suggestions of a practical nature concerning it. The bulletins can be obtained on application to the association.

The National Fire Protection Association has issued the "Proceedings" of its eleventh annual meeting, held last May, in a well-illustrated book of 415 pages. The Association has for its object the improvement of methods of fire protection, and its work is largely of an engineering and architectural nature. It is unusually interesting for two reasons; the first is that upon its recommendations are based in a large degree the rates we must pay for insurance on buildings of all sorts, and the second is that the members of the Association discuss the designs of buildings from a point of view that rarely receives the attention it should. Owing to the amount of information collected by the Association and its affiliated societies concerning the cause and progress of fires in all sorts of buildings, it is able to discuss fire resistance with the aid of information that others do not have. As a result, many of the requirements made by insurance interests seem unnecessarily severe; indeed, it is probably true that they are too burdensome on the intelligent and conscientious contractor and yet fail to hold down the scamp who intends to do crooked work if he possibly can. A perusal of this interesting volume will show, however, that the members of the Association are approaching the problems set before them in a spirit of fairness to all, and when they make severe requirements it is because experience indicates that there is danger. The volume contains information of much value to architects of all types of buildings and to the managers of large industrial establishments who desire to know what is going on in the way of improvement to standard fire-protection apparatus. The volume is published by the secretary of the Association, whose office is at 382 Ohio St., Chicago.

Messrs. Wynkoop Kiersted, consulting engineer, and W. D. Hubbard, of the engineering staff of the Board of Water Supply of New York, have written a volume on "Water Works Management and Maintenance," which will be of value in the offices of all water works departments, public or private, particularly in the Mississippi Valley. Nearly half of the book is a discussion of ground and river supplies and the methods of developing and purifying them, a subject which has received particular attention from Mr. Kiersted for many years and in which he has had unusual success with novel methods and plants. These two chapters give in considerable detail the results of his experience with some of these plants and contain notes regarding the clarification and purification attained by simple coagulation and sedimentation which are particularly valuable. There is a chapter explaining the types and uses of pumping engines and one on impounded supplies in this part of the book; the latter chapter contains the statement that unless the benefits of stripping a reservoir site are liable to be impaired by deposits washed into the reservoir by freshets it is considered advisable to expend funds for the purpose of removing objectionable material from the bottom and sides of an impounding reservoir. Inasmuch as this subject of stripping is one of the most important in water works design at the present time, it might be well in the next edition of the book to embody the substance of the report on stripping made by Messrs. Hazen and Fuller to the Board of Water Supply of New York. The second part of the book is on the maintenance and operation of water works plants. It explains the methods of keeping records, making connections, metering, the prevention of electrolysis, the maintenance of the quality of the supply, the reduction of water waste, the management of repair work, accounting, and other subjects of a similar nature connected with the routine work of a water works office. The book closes with a section on franchises, water rates and depreciation. These are questions that arise mainly in the dealings of private water companies with municipalities, and are becoming of more and more importance on account of the trend of sentiment toward municipal ownership. The senior author has been engaged on many cases in which these subjects were discussed thoroughly and the notes on them which he gives in the book are particularly important in consequence. (New York, John Wiley & Sons, $4.00).

An excellent book on "American Electric Railway Practice" has recently been prepared by Mr. Albert B. Herrick, consulting engineer, and Mr. Edward C. Boynton, general manager of the Orange County Traction Co., for the purpose of bringing together in convenient form a considerable amount of practical information relating to the construction, operation and maintenance of electric railways. No attempt has been made to describe the older types of apparatus or abandoned methods of operation, and as a result the book is an unusually valuable source of information for anybody interested in the subject. While a considerable part of the volume relates to technical subjects, these have been discussed with the idea of showing the "state of the art" rather than the theory. Probably no railway officer will agree with everything in the book, but it contains so much information gathered from the columns of the "Street Railway Journal" and the authors' experience that it will doubtless be of help to all in suggesting improvements in management. The investor in street railway securities who wishes to know something about the details of electric traction properties will find the book particularly useful. The first two chapters are devoted to preliminary estimates and the field engineering methods of interurban railways, and it is interesting to notice that the authors have taken a number of hints from accepted steam railway methods in their discussion of parts of these topics. The location of the power house is next taken up, but no attempt is made to describe power house construction, since that subject is well covered in other books and its introduction here would lead to a great increase in the size of the volume without appreciable increase in its value to most readers. The chapter on the overhead circuit that comes next is a long one, and explains this costly part of an electric railway installation in a manner particularly interesting to steam railway engineers, who generally fail to appreciate its extreme significance. Two chapters follow on train despatching, signals, time tables and schedules, which show that the time is approaching on many electric roads when the complicated schedules of the steam roads will have to be adopted in order to keep traffic moving in accordance with a predetermined plan. The importance of rolling stock is explained in one of the longest chapters in the book, which describes in considerable detail the construction and uses of different types of cars and trucks and gives illustrations of the electric equipment and the wiring. The remaining chapters are on shop design and the maintenance of track, overhead lines and equipment, and various details of the management of men and the collection of fares. (New York, McGraw Publishing Co., $3.00).

Letters to the Editor.

Responsibility for Building Collapses.

Sir.—The numerous collapses of all kinds of buildings that are taking place throughout the country, particularly buildings that are either being constructed or are in course of demolition, ought to result in a more careful consideration of the responsibility for such accidents. When anything of this sort happens, all those concerned stand in a circle and point to the man on the left as the guilty party. There are generally so many of these interested parties and the actual responsibility of each for any part of the work is so indefinite that nobody is punished. This is decidedly wrong, for the killing and maiming of people through careless disregard of safe rules of building is becoming altogether too frequent in our large cities. I do not wish to hold up foreign practice as a model in all respects for American cities, but it is certainly true that the rules of the Prussian government regarding buildings are so complete and so thoroughly enforced that anybody inclined to take chances which endanger life rarely does so, knowing that he will certainly be punished if he does, not with a light fine only but with imprisonment. The building police regulations fix the responsibility of the architect and the contractor and their assistants, and if anything goes wrong there is no question about who shall be punished. Consequently the men who are responsible for the safety of the work really take pains to see that it is safe, except in rare cases, when they invariably are made to suffer for their neglect. The theory is that it is wise to allow builders and contractors full scope of their skill, but their work must conform with the building regulations, and if any accident results from a failure to comply with these regulations, they must bear the penalties for their neglect. It seems to me that American cities are trying too much to pass on the details of plans of proposed structures and are not giving enough attention to defining the responsibilities of those engaged in building operations.

Very truly yours,

Observer.

The Operation of Water and Sewage Purification Plants.

Sir.—Will you allow me to suggest through your columns that a number of American cities are showing a poor appreciation of their responsibilities in health matters to their people in the way they operate the plants for sewage and water purification that have been built by them at considerable expense. Some time ago I had an opportunity of visiting a number of plants in the Central States and found that most of them were without proper supervision and a few were allowed to run without any supervision at all, except such as could be given by an ignorant laborer. I have also seen a number of water purification plants that needed careful attention, owing to the fluctuations in the character of the water or the large amount of sedment in it, run by rule of thumb in such a way that they could not be of much use.

It seems to me that the engineers who design such plants do not lay enough stress as a rule on the importance of operating the plants properly. When the authorities of a city take over a sewage disposal plant, they generally have the opinion that it is something which is important but rather offensive as a scene of daily work, so that good men will not take it up, and accordingly adopt a scale of wages for the attendants which is not enough to secure competent men. In a little while something goes wrong, the neighbors raise a cry, and the authorities are so disgusted with the result of the large initial expenditure for the works that they leave them to shift for themselves. Probably a little competent attention and cleaning up would bring the plant to rights again, but it will probably never get it unless there is a powerful State Board of Health to force the city to act or the people in the neighborhood of the works take the matter into the courts.

Most consulting engineers do not need to be told that the average city looks upon their modest charges for professional services as very high, for there is still a lurking impression that the only difference between the engineer who dwells in a large office and the engineer who looks after a steam plant in a shop is in their respective incomes. It is hard enough in most cases to collect reasonable fees for mere designs, yet public health would be much advanced if the designers of water and sewage purification plants strongly urged their clients to turn the operation of these plants, for a period of two to five years at least, over to them at a fixed annual compensation, they to furnish all attendants. Such plants require expert supervision when first started up more than at any other time, and by giving them this supervision the experts will be able to train local assistants so thoroughly that at a later date, when the operation of the plant under local conditions is fully understood, the management will be reduced to a minimum as respects cost.

Yours truly,

Sanitarian.